PRELIMINARY REPORT =

Fifth annual Report

OF THE

UNITED STATES GEOLOGICAL SURVEY

OF

MONTANA

AND

PORTIONS OF ADJACENT TERRITORIES;

BEING A

FIFTH ANNUAL REPORT OF PROGRESS.

BY

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U.S. Geol. & geog. survey of the territories

CONDUCTED UNDER AUTHORITY OF THE SECRETARY OF THE INTERIOR.

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LETTER TO THE SECRETARY.

WASHINGTON, D. C., *February* 20, 1872.

SIR: In accordance with your instructions, based upon the act of the Forty-first Congress, authorizing the continuation of the geological survey of the Territories of the United States, I have the honor to submit my fifth annual report of progress.

As soon as the season was sufficiently far advanced to admit of explorations in the mountain districts, I dispatched my principal assistant, Mr. James Stevenson, to Omaha and Cheyenne, to make the necessary preparations and secure the outfit.

My party was organized as follows: James Stevenson, managing director; Henry W. Elliott, artist; Prof. Cyrus Thomas, agricultural statistician and entomologist; Anton Schönborn, chief topographer; A. J. Smith, assistant; William H. Jackson, photographer; George B. Dixon, assistant; J. W. Beaman, meteorologist; Prof. G. N. Allen, botanist; Robt. Adams, jr., assistant; Dr. A. C. Peale, mineralogist; Dr. C. S. Turnbull, physician; Campbell Carrington, in charge of zoological collections; William B. Logan, secretary; F. J. Huse, Chester M. Dawes, C. De V. Negley, and J. W. Duncan, general assistants. Mr. Thomas Moran, a distinguished artist from Philadelphia, accompanied the party as guest, to secure studies of the remarkable scenery of the Yellowstone. In addition to the above, there were about fifteen men who acted as teamsters, laborers, cooks, or hunters. The greater portion of our outfit was obtained of the United States quartermaster, Colonel C. A. Reynolds, at Fort D. A. Russell, Wyoming Territory. Horses, mules, wagons, and all other equipments were placed on freight-cars and taken by rail to Ogden, Utah. Here our journey began.

About June 1, leaving Ogden, we passed along the shore of Salt Lake to Willard City, thence through the Wasatch Range to Cache Valley, thence up the valley to the divide, between the waters of the Salt Lake Basin and those of Snake River. A careful survey of the valley was made, and frequent trips into the mountains on either side were taken. We then descended Marsh Creek to the Snake River Basin and Fort Hall. Here we rested for two days, to recruit our animals and make the necessary repairs, and then followed the stage-road to Virginia junction. We then left the stage-road to the westward, taking an old road, crossed Blacktail Deer Creek near its source, thence down Stinking Water to Virginia City. We then crossed the divide eastward to the Madison river, descended the valley about thirty miles, and crossed over the other divide to Fort Ellis, at the head of the Gallatin Valley. A narrow belt was thus surveyed, con-

necting the Pacific Railroad with the Yellowstone Basin, our principal field of operation. From Fort Ellis, we passed eastward over the divide, between the drainage of the Missouri and Yellowstone, to Bottler's Ranch. Here we established a permanent camp, leaving all our wagons and a portion of the party. A careful system of meteorological observations was kept at this locality for six weeks. From Bottler's Ranch we proceeded up the valley of the Yellowstone, surveyed the remarkable hot springs on Gardiner's River, the Grand Cañon, Tower Falls, Upper and Lower Falls of the Yellowstone, thence into the basin proper, prepared charts of all the Hot Spring groups, which were very numerous, and continued up the river to the lake. We then commenced a systematic survey of the lake and its surroundings. Mr. Schönborn, with his assistant, made a careful survey of the lake and the mountains from the shore, and Messrs. Elliott and Carrington surveyed and sketched its shore-lines from the water in a boat. Careful soundings were also made, and the greatest depth was found to be three hundred feet. From the lake I proceeded, with Messrs. Schönborn, Peale, and Elliott to the Fire-Hole Valley, by way of East Fork of the Madison; then ascended the Fire-Hole Valley. We made careful charts of the Lower and Upper Geyser Basin, locating all the principal springs, and determining their temperatures. We then returned over the mountains by way of the head of Fire-Hole River, explored Madison Lake, Heart Lake, &c. After having completed our survey of the lake, we crossed over on to the headwaters of the East Fork by way of the valley of Pelican Creek, explored the East Fork to its junction with the main Yellowstone, and thence to Bottler's Ranch, which we reached on the 28th of August. From this place we passed down the Yellowstone, through the lower cañon, to the mouth of Shield's River, to connect our work with that of Col. Wm. F. Raynolds, in 1860. From there we returned to Fort Ellis. From this point I desired to examine a belt southward to the Union Pacific Railroad, that should connect, as far as possible, with the belt explored on our way up to Fort Ellis in June. We therefore passed down the Gallatin Valley to the junction of the Three Forks, thence up the Jefferson Fork to the Beaver Head branch, then up the Beaver Head to Horse Plain Creek, up the latter creek to the main Rocky Mountain divide, thence across to the headwaters of the Medicine Lodge Creek into the Snake River basin and Fort Hall. From Fort Hall we struck across the mountains between Black-Foot Creek and the source of the Port Neuf to Soda Springs, at the head of Bear River; examined the Soda Spring district, and passed up the valley of Bear River, by way of Bear Lake, to Evanston, on the Union Pacific Railroad. At this point the party was disbanded, most of them returning to their homes. A portion of the month of October was occupied in reviewing points of geological interest along the railroad.

Extensive collections in geology, mineralogy, botany, and all departments of natural history were made, some account of which is given in subsequent portions of this report.

Although my party the past season was unusually large, involving increased labor and responsibility in its management, I gladly bear testimony to the uniform zeal and interest of the members in its success.

My principal assistant, Mr. James Stevenson, labored with his usual efficiency and fidelity throughout the entire trip. In honor of his great services not only during the past season, but for over twelve years of unremitting toil as my assistant, oftentimes without pecuniary reward, and with little of the scientific recognition that usually comes to the original explorer, I have desired that one of the principal islands of the lake and one of the noble peaks reflected in its clear waters should bear his name forever.

Mr. Elliott labored with his usual zeal and efficiency, and, besides great numbers of sketches, he constructed sections of the entire routes traversed during the season. Assisted by Mr. Carrington, he made the circuit of the lake in our little boat, and sketched the entire shore-line with care.

Mr. William H. Jackson performed his duties with great zeal, and the results of his labors have been and will continue to be of the highest value. During the season he obtained nearly 400 negatives of the remarkable scenery of the routes, as well as the cañon, falls, lakes, geysers, and hot springs of the Yellowstone Basin, and they have proved, since our return, of very great value in the preparation of the maps and report.

Dr. C. S. Turnbull acted as physician and general assistant, and by his great fidelity in the performance of his duties rendered himself a useful and valued member of the party.

Mr. Campbell Carrington had charge of the zoological collections during the years 1870 and 1871, and performed his duties with great zeal and efficiency. His collections of fish and reptiles are quite complete. He was assisted by Messrs. Dawes, Logan, Negley, and Duncan.

The reports of Professor Thomas and Dr. Peale, which are herewith appended, will speak for themselves. Prof. G. N. Allen acted as botanist with great success, as far as Fort Ellis, and was assisted by Mr. Robert Adams. After Prof. Allen's departure, Mr. Adams took charge of the botanical collections. The report of Prof. Porter will show the results of their labors in the field.

The loss of my chief topographer, Mr. Anton Schōnborn, whose death occurred at Omaha after he had returned from the trip, with the notes which he had taken with zeal and ability, seemed almost irreparable. On my arrival at Washington I applied to Prof. J. E. Hilgard, the able assistant in charge of the United States Coast Survey Office, for aid in my extremity. With his usual sympathy and prompt action in all matters pertaining to science, he at once placed Mr. Schönborn's field-notes into the hands of Mr. E. Hergesheimer, in charge of the engraving division of the Coast Survey, and the result has been that Mr. Hergesheimer has compiled and drawn a series of maps and charts of the survey, whose beauty and accuracy attest his skill as a topographer. Prof.

Reuel Keith, of the Coast Survey, computed the observations for latitude and time. Mr. Beaman has been permitted to consult from time to time with Mr. Charles A. Schott, in the preparation of the meteorological report. I cannot too earnestly express my obligations to the officers of the Coast Survey for their aid and counsel.

In all my previous reports I have acknowledged my obligations to the military authorities for favors of great value. Armed with orders from the honorable Secretary of War, General Belknap, upon the military posts of the West for such assistance as could be afforded without detriment to the service, my whole party was everywhere received with marked kindness and generosity. The outfit obtained from Colonel C. A. Reynolds, of Fort D. A. Russell, Wyoming Territory, was even greater and more complete than that of the preceding year, and the aid which both himself and his subordinates cheerfully gave us, formed one of the most important elements of our success. An outfit so suitable for our purpose could not have been purchased in the country outside of the Quartermaster's Department, however great our appropriation. We were also permitted to purchase commissary stores at cost with transportation included. The amount of time and money saved to the General Government, as well as the character of the outfit, render these favors essential to the complete success of a party exploring the remote sections of the interior of our continent. We are also saved from extortionate demands that might be made on us in case of an emergency which may at any time occur. At Fort Ellis we were indebted more or less to all the officers of the post for courtesies, but I beg to make special mention of Captain J. Q. Ball, who was in command in the absence of Colonel Baker, on our arrival there. Captain Ball at once gave us all the assistance that could be afforded by the post, and the benefit of his long experience in western life, in the completing of our equipments. On our return to Fort Ellis we were much aided by Captain L. C. Forsyth, quartermaster of the post. By orders of Generals Sheridan and Hancock, one company of the Second Cavalry, under the command of Captain Tyler and Lieutenant Grugan, was directed to escort the party, under the direction of Colonel J. W. Barlow and Captain D. P. Heap, United States Engineer Corps, and the party under my charge. Captain Tyler and Lieutenant Grugan remained with us until we reached the Yellowstone Lake, when they were ordered to return to Fort Ellis, and Lieutenant G. C. Doane was directed to take their place. I wish here to thank Captain Tyler and Lieutenant Grugan for unvarying courtesy and a desire to advance the objects of our expedition in every way during their stay with us. Lieutenant Doane reached us at our camp on the southwest shore of the lake, and from that period to the time of our return to Fort Ellis we received the benefit of his experience of the previous year.

From Captain J. E. Putnam and Lieutenant Wilson, of Fort Hall, my

entire party were the recipients of all the assistance we needed or the post could supply. To my excellent friend, General H. A. Morrow, in command of Camp Douglas, Utah, I am indebted for many favors, not only as an officer of the Army, but as an earnest and successful student of geology, in the form of valuable specimens and much information. To the officers of the railroads and stage-lines my party was much indebted the past season. To Mr. Bradley Barlow, and Gilmer and Salisbury, proprietors of the stage-routes in Idaho and Montana, our thanks are due for passes for two persons.

I beg to call the special attention of the Department to the great generosity of the officers of the Union Pacific Railroad, Hon. Thomas A. Scott, president, and General T. E. Sickels, superintendent, for free transportation for my entire party from Omaha to Ogden, and return. Mr. H. Brownson, general freight-agent of the Union Pacific Railroad, ordered our freight to be carried at reduced rates. My thanks are also due to the officers of the Central Pacific Railroad for free passes for several members of my party.

It would not be possible to mention by name, all the kind friends in the West who showed my party valuable attentions. With scarcely an exception, we were received with great favor in every portion of the country. I would express my thanks to Hon. B. F. Potts, governor of Montana, Hon. H. L. Hosmer, Hon. J. Y. Lovell, of Virginia City, and many others.

I wish also to express my obligations to the gentlemen connected with the press, who have never failed to recognize the importance of these surveys in the development of our western Territories.

I desire to acknowledge the numerous favors and aid which have always been extended to myself and party in all our labors by Professors Henry and Baird, of the Smithsonian Institution, and to the Engineer Bureau of the Army, for the use of their valuable maps for several years past.

To the editors of Scribner's Monthly, who have done and are continuing to do so much to spread a knowledge of the remarkable scenery and resources of the far West among the people, I am under obligations for the use of some of the finest wood-cuts illustrating this report.

As far back as 1856, when the writer was connected with the exploring expedition to the Lower Yellowstone, under the command of General G. K. Warren, of the United States Engineer Corps, it was the plan of that accomplished engineer and geographer to penetrate the unknown but marvelous region of the Yellowstone Basin. Wonderful tales, that had sharpened the curiosity of the whole party, were related by our guide, Mr. James Bridger. An expedition was planned by General Warren for the years 1859 and 1860, which contemplated the exploration of this region as the objective point; but he was superseded in command by Colonel Wm. F. Raynolds, of the United States Engineer Corps. The writer was also connected with that expedition as geologist. Every

effort was made by Colonel Raynolds to cross the snow-covered summits of the Wind River Mountains, but without success. In the summer of 1869, a small party, under Messrs. Cook and Folsom, ascended the Valley of the Yellowstone, to the lake, and crossed over the divide into the Geyser Basin of the Madison.

In the summer of 1870, a second party, under General Washburn, surveyor general of Montana, visited that country. Mr. N. P. Langford, a member of the party, gave, in the May and June numbers, 1871, of Scribner's Monthly, most glowing accounts of the marvelous wonders. These articles called the attention of the whole country to that remarkable region. Lieutenant G. C. Doane, Second Cavalry, United States Army, accompanied the party in command of a small escort, and made an official report of the trip to General Hancock, who forwarded it to the honorable Secretary of War, General Belknap, who at once transmitted it to Congress, with a request that it be printed. I desire to call the attention of the public to the remarkable report of this young officer, which he seems to have written under the inspiration of the wonderful physical phenomena around him. The report is a modest pamphlet of 40 pages, yet I venture to state as my opinion, that for graphic description and thrilling interest it has not been surpassed by any official report made to our Government since the times of Lewis and Clarke.

Colonel J. W. Barlow, United States Engineer Corps, on General Sheridan's staff, and Captain D. P. Heap, United States Engineer Corps, on General Hancock's staff, made an exploration of the Yellowstone Basin during the past season, the results of which will doubtless soon be given to the public in an official form. A very interesting and instructive abstract has already appeared in the Chicago Journal of January 13.

In attaching names to the many mountain-peaks, new streams, and other geographical localities, the discovery of which falls to the pleasant lot of the explorer in the untrodden wilds of the West, I have followed the rigid law of priority, and given the one by which they have been generally known among the people of the country, whether whites or Indians; but if, as is often the case, no suitable descriptive name can be secured from the surroundings, a personal one may then be attached, and the names of eminent men who have identified themselves with the great cause, either in the fields of science or legislation, naturally rise first in the mind.

The wisdom of the policy of publishing for the people the immediate results of my surveys, in the form of annual reports, even though somewhat crude, has received emphatic sanction by the great demand for them in past years and the general satisfaction they have given. I have, therefore, made them the receptacle of a mass of observations on the local geology of the routes which I cannot introduce into a more elaborate final report. The attempt, also, to give to these annual reports a somewhat popular as well as scientific cast has met with the cordial

approval of the students of geology and natural history all over the country. I trust, therefore, that they may be continued from year to year, as long as the survey shall receive the sanction of the Government.

The annual report will contain catalogues of species which will be useful in determining the geographical distribution of plants and animals in the West, the meteorological observations, and all the notes of a more practical character on the agricultural and mining resources, &c.

The final reports will be in quarto form, and will contain only the new and little-known species of that region requiring detailed description and illustration, the general geology, with maps, sections, and other illustrations.

The type series of the collections in all departments are arranged in the museum of the Smithsonian Institution, according to act of Congress.

The duplicate specimens are then separated into sets, and distributed to the various museums and institutions of learning in our country.

I would respectfully call the attention of the Secretary to the names of men eminent in the scientific world, connected with the special articles in my annual report of this year as well as that of last year. The investigations of such men as Leidy, Cope, Lesquereux, Newberrry, Meek, Porter, Uhler, Horn, and Edwards, will give to these reports a lasting value for all time. These gentlemen have generously consented to become collaborators for the final reports, and are now preparing memoirs on special branches, which will form solid and permanent contributions to knowledge. The obligations to these gentlemen are increased from the fact that the greater part of the work is a "labor of love," without any compensation from the Government.

In conclusion, I beg permission to extend to the Secretary of the Interior and to General B. R. Cowen, Assistant Secretary, my most grateful thanks for the generous facilities they have placed at my command, and for the kindly interest they have ever felt in the progress of the work. If these explorations in the far West shall tend to the honor of our country or to the increase of human knowledge, the main object will be attained.

Very respectfully, your obedient servant,

F. V. HAYDEN,
United States Geologist.

Hon. C. DELANO,
Secretary of the Interior.

PART I.

REPORT OF F. V. HAYDEN.

CHAPTER—

I. FROM OGDEN, UTAH, TO FORT HALL, IDAHO.

II. FROM FORT HALL, IDAHO, TO FORT ELLIS, MONTANA.

III. FORT ELLIS—MYSTIC LAKE—SOURCE OF THE GALLATIN—TRAIL CREEK—CROW AGENCY AND FIRST CAÑON—EXIT OF THE YELLOWSTONE.

IV. FIRST CAÑON—SNOWY RANGE—EMIGRANT PEAK—BOTTLER'S RANCH—SECOND CAÑON—DEVIL'S SLIDE—WHITE MOUNTAIN—HOT SPRINGS, ETC.

V. THE GRAND CAÑON—FALLS—HOT SPRINGS—YELLOWSTONE LAKE.

VI. FROM YELLOWSTONE LAKE TO THE GEYSER BASINS OF FIRE-HOLE RIVER AND RETURN.

VII. FROM HOT SPRING CAMP, ON YELLOWSTONE LAKE, UP PELICAN CREEK AND DOWN EAST FORK, TO BOTTLER'S RANCH.

VIII. FROM FORT ELLIS TO SNAKE RIVER BASIN, IDAHO.

IX. FORT HALL—SODA SPRINGS—BEAR RIVER VALLEY—BEAR LAKE VALLEY—TO EVANSTON, ON UNION PACIFIC RAILROAD.

X. THE YELLOWSTONE NATIONAL PARK, WITH A MAP.

XI. PRELIMINARY REPORT OF DR. A. C. PEALE ON MINERALS, ROCKS, THERMAL SPRINGS, ETC., OF THE EXPEDITION.

ERRATA.

Page 29, sixteenth line from the bottom, for "Hole in the Wall" read "Hole in the Rock."

Page 64, twenty-fourth line from the top, for "estsary" read "estuary."

Page 71, third line from the top, after "flow from" read "it."

Page 72, thirty-first line from the top, for "150" read "1,500."

Page 73, fifteenth line from the top, for "cleaving" read "dissolving."

GEOLOGICAL SURVEY OF THE TERRITORIES.

CHAPTER I.

FROM OGDEN, UTAH, TO FORT HALL, IDAHO.

In my previous reports I have endeavored to present such facts in regard to the geology of the country lying between Omaha and Salt Lake as my time and opportunities have enabled me to secure. In a subsequent chapter I shall pass this region again under review, adding such new matter as the investigations of the past seasons have brought to light.

In order that the results of the explorations of 1871 might be connected with those of preceding years, it was thought best to make Ogden the point of departure. The latitude and longitude of Salt Lake City are probably as well fixed as those of any point west of the Mississippi. The elevations taken along the line of the Pacific Railroad were assumed to be correct, and the geography as well as the geology of Salt Lake Valley were known in general terms. Our camp was located on a middle terrace one mile east of Ogden Junction, at an elevation above tide-water of 4,517 feet. Extending along the eastern side of the valley, with a trend nearly north and south, is a lofty and picturesque range of mountains—the northern section of the Wahsatch Range. Far southward, beyond the southern end of the Great Salt Lake, these mountains seem to extend, apparently growing more lofty and more picturesque, a gigantic wall inclosing one of the most beautiful valleys in the West. From the terraces, which form a conspicuous feature along the base of these mountains, one can obtain a full view of the wonderful body of water which has given name and character to this region. I will not attempt here to describe the scenic beauty of this region; it has already been done many times; it must be seen by the traveler to be understood, and once impressed upon the mind it becomes a perpetual pleasure thereafter.

The discussion of the Post-Pliocene deposits and other prominent geological features of this valley is reserved for a subsequent portion of this report. It is my purpose at this time simply to note the impressions obtained of the geological structure of the country from point to point in the journey northward from Ogden to the valley of the Yellowstone.

The range of mountains which form so conspicuous and attractive a feature along the eastern shore of the lake, and north from Ogden, is composed mostly of quartzites and limestones, which present excellent examples of stratification. Just in the rear of our camp there is an illustration in which a thousand feet or more of layers of quartzite, varying from a few inches to several feet in thickness, are bent in the form of an arch (Fig. 1) as if the force had been applied from beneath, near the central portions, but that the sides or ends had lopped down for want of support. There are many examples of these peculiar features in this range, produced by local influences, but connected with the general

forces that elevated the entire range. These mountains appear to the eye, in viewing them from the valley, as if they had been thrust up out of the plains. The sides are very abrupt, in many instances varying but little from a vertical. So far as I could study them, north of Ogden they form a monoclinal, the eastern side shown in its full development, and all the rocks having a general dip to the east, or nearly so. The abruptness or steepness of the west side toward the lake is undoubtedly due to this fact, as the outcropping edges of the strata are clearly shown on the side toward the lake, while to the eastward the ridges of upheaval extend for miles, gradually sloping to the plains. Whether the west portion was ever elevated or has been removed by erosion is not clearly revealed. This problem will be discussed at another time. Where the Weber River passes through the Wahsatch Mountains a nucleus of gneiss is exposed, but in this portion of the range the granitic or gneissic rock is exposed only in a few localities, and then only to a limited extent. These examples are sufficient to show that the quartzites, limestones, and other sedimentary rocks above rest upon what we have regarded as well-defined metamorphic rocks similar to the nuclei of other mountain ranges. A few instances occur of igneous outbursts, like those in the southern extension of the Wahsatch Mountains, but very

Fig. 1.

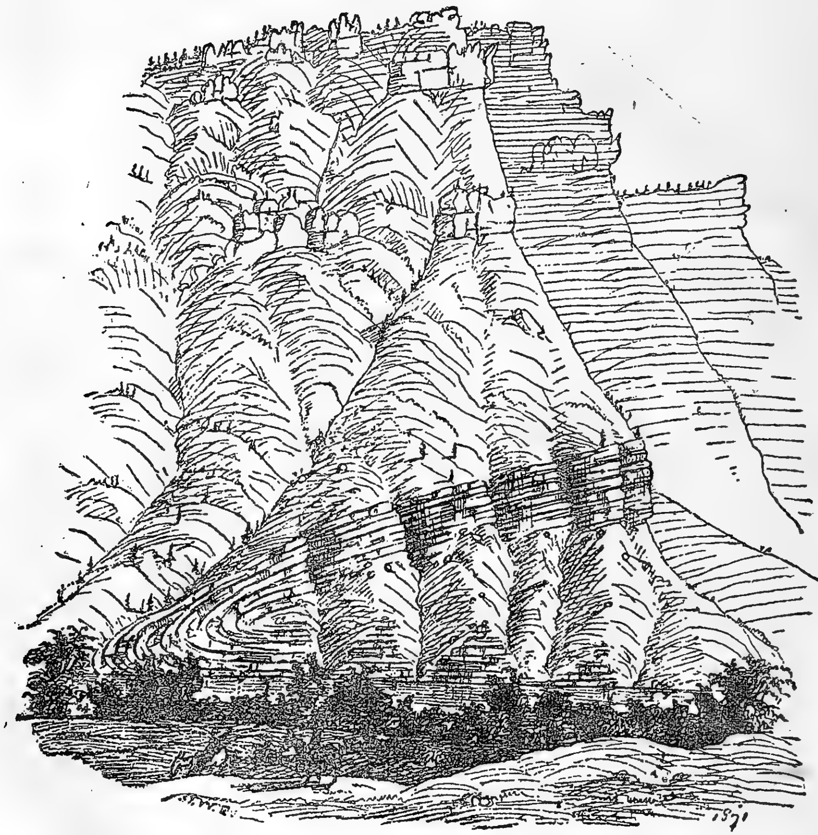
limited in extent. The lowest bed of quartzites resting upon the granitoid rocks I have estimated to be 1,500 to 2,000 feet in thickness. It has a very brittle fracture, although so hard and compact, usually very fine, and, to the naked eye, without grain, but it is sometimes composed of an aggregate of water-worn pebbles, mostly quite small, or crystals of quartz. This lower bed has evidently been more or less changed by heat, and the external evidence of change grows fainter as we proceed up from the quartzites into the limestones, until all traces of it disappear. In regard to the age of these quartzites there is much obscurity. So far as my own investigations are concerned, I only know that they attained a great thickness—that they seem to form the lower portion of the shaly sedimentary rocks of this region. The discovery of the well-known Silurian coral, *Halysites catenularia*, in the last bed of limestone, points to a Silurian horizon. The texture of the rocks in these mountain ranges renders the discovery of fossils in great numbers and in a good state of preservation quite doubtful. We shall wait for the report of the more careful investigations under the direction of Mr. Clarence King. The Carboniferous group in this region is well defined by its fossils, and I have no doubt that the Silurian and Devonian are well represented. It may be that all the lower quartzites should be embraced in the Silurian. If opportunity presents, I hope to discuss these obscure points more in detail in the closing chapter of this report.

The same remarkable illustrations of mud-flats and shallow water deposits as occur in the quartzites of the Uintah Mountains are seen here. Some of the layers are closely crowded with rather coarse fucoidal stems or roots, suggesting the Devonian age. As is quite well shown on our maps, the ranges of mountains west of longitude 111° have a trend nearly north and south, or perhaps, more accurately, west of north and east of south. Many of the little streams that empty into the lake pass through the Wahsatch Range at right angles, or nearly so, thus forming the deep and picturesque cañons for which this basin is so remarkable. Cross-sections of the mountains are thus exposed, enabling the geologist to work out with considerable clearness the order of superposition of the beds; though, with all these advantages, it is not always an easy task. Sometimes the strata are much crushed and folded, or concealed by recent deposits or *débris*.

On the morning of June 4, I made an exploration up Ogden Cañon, which forms an excellent example of the cross-sections referred to above. A fine creek about 30 feet wide and 3 to 5 feet deep has cut a channel through the mountain and its ridges. The stream, as it comes out of the mountain on the west side, opens into a broad grassy valley, thickly settled by farmers, and joins the Weber River about five miles distant. Five miles from the entrance of the cañon to the eastward there is an expansion of the valley, with table-like terraces on the north side, on one of which a Mormon village is located. The terraces are 30 to 50 feet above the bed of the creek. On the northeast side of this valley are hills 800 to 1,000 feet high, composed of arenaceous clays, with some beds of limestone, while east and southeast are numerous ridges of limestones with corals and other fossils, showing them to be of Carboniferous age. The north and northeast sides of the hills are rounded and sloping, and covered with coarse bunch-grass and small bushes. The valley is full of springs and meadow-like areas. The scenery can hardly be surpassed in any country for wild, picturesque beauty. The character of the rocks in the order of superposition does not differ materially from those exposed in the valley of the Weber River, along the line of the Union Pacific Railroad. There are the Tertiary beds of the Wah-

satch group about the sources of Ogden Creek; then the low Jurassic ridges, inclining 10° to 15°, gradually passing down into sandstones, quartzites, then arenaceous limestones, changing gradually to pure massive limestones of Carboniferous age. As we pass down the cañon from Ogden Valley, or, as it is named on our maps, Ogden Hole, we observe the Carboniferous limestones rising like high, nearly vertical, walls on either side, at first inclining about 8°, within ten miles dipping 20° to 30°, and 1,500 to 2,000 feet in thickness. In these limestones are some remarkable illustrations of the folding of the strata, (Fig. 2.) In one locality there is a

Fig. 2.



WEDGE OF LIMESTONE, OGDEN CAÑON.

group of strata, perfectly cross-sectioned by the stream, 300 feet long and 200 feet high at the thickest end, in the shape of a huge wedge. Underneath these limestones comes a yellowish-gray quartzite, which forms a portion of a ridge inclining 20° to 25°. A small gulch intervenes, and the next ridge runs up like a cone with a dip northeast 55°, and the strata are brought out remarkably clear, with a height of 1,500 to 2,000 feet; beneath the quartzite is another bed of brittle limestone of better quality than the other, of a bluish-gray color, passing down into a steel-gray. The coarse portion is quite slaty. It is this bed that furnishes the material for burning into lime. These limestones incline 30°, and are about 1,500 feet in thickness. The next bed is composed

of rusty-brown slaty clays 200 feet thick. Then succeeds a remarkable group of quartzite beds, with unusual indications of shallow water deposition, inclining 75°. The river cuts directly through the ridge, forming a cañon 100 feet wide, with walls 500 feet high. The lower bed I have estimated at 2,000 feet in thickness, and it is mostly a close-grained compact quartzite, but sometimes it is an aggregate of small white masses of quartz and water-worn pebbles. From underneath this bed are a few outcroppings of micaceous gneiss and reddish feldspathic granite, apparently inclining the same with the quartzites.

There is another very interesting feature in this cañon which connects it more immediately with the great valley to the west of the range. Toward the sources of Ogden Creek, and in the expansions of the valley, are quite thick deposits of a kind of drift of sands and clays, with the greatest abundance of loose, worn bowlders and pebbles. In the cañon this drift material forms a massive, coarse conglomerate, and fragments now are found attached to the sides of the cañon in a horizontal position. These conglomerates point to the time when the great fresh-water lake, at a comparatively modern period, filled the valley of Salt Lake high upon the flanks of the mountains, even covering the highest terrace.

This subject will be discussed more fully in a subsequent portion of this report.

On the morning of June 11, we left our camp near Ogden City and proceeded on our journey northward, camping the first night near the Hot Springs. This is a very interesting locality, and deserved a more careful study than we were able to give it. There is here a group of warm springs, forming, in the aggregate, a stream 3 feet wide and 6 to 12 inches deep; the surface, for a space of 300 or 400 yards in extent, is covered with a deposit of oxide of iron, so that it resembles a tan-yard in color. The temperature is 136°. They flow from beneath a mountain called Hot Spring Mountain, which is about five miles long and three wide, and is, I think, a remnant of the west part of the anticlinal of which the great range forms the eastern part. On either side of this fragment of a mountains the terraces are distinctly defined. The nucleus is composed of micaceous gneiss, with seams of white quartz running through it in every direction, and resting upon it with apparent conformity are the quartzites and limestones. The elevation of the shore of the lake near the water-tank, not far from Hot Springs, is 4,191.4, while the highest point of this broken mountain to the east of it is 4,986.6, or about 800 feet above the lake. The water of the warm springs is as clear as crystal, containing great quantities of iron, and the supply is abundant, and as there are cold springs also in the vicinity, there is no reason why this locality should not at some future period become a noted place of resort for invalids. The medicinal qualities of the water must be excellent, and the climate is unsurpassed.

Between Willard City, and Brigham City the terraces are well defined, and the sides of the mountains, as the edges of the strata project toward the lake, present a remarkably rugged appearance. The limestones crop out here and there upon the quartzites without any regular dip. I sought earnestly for some unmistakable proof that this fragmentary mountain is a remnant of the west portion of the anticlinal, and though I am convinced that it is so, yet the evidence was not as clear as I could wish. The terraces, as well as the sides of the mountains, are covered so thickly with a kind of local drift or a modern lake deposit that the underlying rocks are concealed. Near Box Elder Cañon are two kinds of terraces, the usual lake terraces, of which there

are two well-defined lines at least, and the river terraces, which are confined to the streams and do not seem to have any direct connection with the former. These river terraces are so marked a feature in the landscape that they would not be overlooked by the traveler. The lowest plain valley opposite the cañon, near the water's edge, was found to be 4,344.8 feet above the sea-level. First terrace, 4,683.8 feet; second terrace, 4,776.5; third terrace, 4,858.9. These terraces will show more clearly than any other evidence we have, the gradual decrease, step by step, of the waters of the ancient lake, and the operations of the little streams pouring into it from the mountains on either side. The amount of local drift that has been swept down through the gorges or cañons and lodged at the opening is very great. At the immediate mouth of the cañon the bowlders are quite large, varying in diameter from a few inches to several feet. As we travel westward toward the shore of the lake the bowlders diminish in size and quantity, and the finer sediments, as sands and marls, increase, showing a constant decrease in the power of the currents of the water after leaving the mouth of the cañon. Ascending the Box Elder Cañon we find the sides almost vertical, rising to a height of 1,500 to 2,000 feet. The rocks are gneiss, quartzites, slates; these quartzites again inclining 30° to 70°. After passing up the narrow gorge for about two miles in a straight line, with just room for the little stream, with the road with the lofty precipitous rugged walls on either side, we come out into an open park-like area, about three miles in extent from east to west and four miles from north to south, which forms a level plain about 900 feet above Salt Lake. On the east side of the park there is a great thickness of alternate layers of slaty shale and rusty-yellow quartzites, varying in thickness from one-fourth of an inch to twenty inches, inclining northeast at an angle of 45°, and one is an immense thickness of steel-blue limestone, which projects up near the summit of the hills, in sharp, craggy pinnacles. In these limestones is an abundance of *Syringopora*, *Fenestella*, *Spirifer*, *Productus*, sufficient to show that they are of Carboniferous age. Upon the surface of the layers of quartzites beneath are impressions of what appear to be sea-weeds in the greatest abundance, so that large masses of the rock, which is in many instances a sandstone, with a reddish tinge, look like the Medina sandstone of New York, covered with the *Arthrorophycus Harlani*.

In the park the river terraces are well defined, really constituting the arable land in the mountains.

The little Danish Mormon village of Copenhagen is located on a terrace in this park. The farms of the settlers are in common, and are cultivated by irrigation with success. To show how much available land there is, we estimated it at twelve square miles, or over 7,000 acres. The park is surrounded by high mountains, which protect it from great extremes of temperature, and the elevation above the sea is 4,958 feet. The mountainous portions of Northern Utah are full of these beautiful park-like areas, which are most probably the remains of an ancient lake. The wells which have been dug by the settlers show a considerable amount of drift or bowlder deposit, with fine white or yellow marly sands and clays in regular layers, showing the deposit to be Post-Pliocene, and that the waters of the lake were comparatively quiet. The interesting features of this park are the large springs at the base of the high hills which surround it. On the south side there is a spring of very pure cold water, flowing out from beneath limestone mountains, forming a stream of 10 feet wide and 1 foot deep, supplying water for irrigating a large part of the park. On the north side there is a spring about the same size as the others. Other springs occur often, so that this little park is intersected with small streams in every direction.

From Mantua to Wellsville, in Cache Valley, the surface of the country on either side of the road is very rugged. The rocks are mostly limestones. The road runs between two ridges of upheaval, or a monoclinal valley, with the bluish, cherty, brittle limestone rising up 1,500 to 2,000 feet on the west side, inclining a little north of east at a very large angle, while on the east side the hills are more rounded, 800 to 1,000 feet above the general level of the country, but dipping in the same direction. The range of mountains west of Wellsville must average 1,500 feet in height; down the valley are one or two of the highest peaks—over 2,000 feet—which are covered with snow in midsummer. They are composed almost wholly of limestones and quartzites. To the eastward the ridges reach to an unknown distance, becoming lower and the strata inclining at a smaller angle. Instead of beds of massive limestone, there are alternations of arenaceous clays, limestones, and sandstones, yielding more readily to atmospheric influences, and in consequence the hills are more rounded and covered with grass or small trees. I have estimated the entire thickness of the stratified rocks in this region at 10,000 feet, and it is with this mass that we have to deal at this time. This estimate does not include the Tertiary beds, either modern or ancient, which are nearly always present in some form.

Cache Valley opens into Salt Lake Valley by way of Bear River Bay, and one cannot doubt that the lake itself formerly extended all over Cache Valley. The modern Tertiary or Pliocene deposits which cover the valley jut up against the mountains on all sides, with the terraces which are distinct, although not so strongly marked as in Salt Lake Valley. Most of the building rocks at Wellsville are the soft sandstones of the modern deposits, which I have, in a former report, called the Salt Lake group. Compact, rusty brown quartzites enter into the walls of the houses to considerable extent; but for sills, corners, chimney-tops, and other ornamental purposes, the whitish-gray and gray-brown sandstones are used, from the fact that they are very durable, and can be wrought into any desirable shape. These calcareous sandstones are horizontal, and underlie the plateaus or terraces in the valley. The quarry near Wellsville is not profitable, as the principal layer of rock is not more than 12 or 14 inches in thickness, and several feet of superficial gravel and marl have to be removed before the sandstone can be obtained. Near Mendon the sandstone is much more compact, and occurs in several layers. It is quite white, and forms very beautiful walls. It varies much in texture, some of it very porous, but it is, for the most part, close-grained enough for durability. It is in some instances a perfect Oolite. At Logan the principal co-operative store, a large two-story building, is constructed of a rock from this group, which is made up of an aggregate of fresh-water and land shells of the genera *Limnea*, *Physa*, *Vivipara*, *Helix*, &c., apparently identical with recent species. I was informed that this rock comes from the foot-hills of the mountains just west of Mendon. It is the upper layer, and is a light-brown calcareous sandstone. The shells are nearly all casts, the rock being so porous in texture that the calcareous shell is in most cases dissolved out. The ridge of elevation, or range of mountains, as it might more properly be called, which forms the eastern wall of Cache Valley, breaks off suddenly near Mendon, and from thence northward it appears in detached portions and of far less magnitude. But the range or ridge which walls in the east side is lofty and continuous. To gain some knowledge of its structure, I ascended Logan Cañon about four miles in a straight line above its mouth. The cañon seems to be due partly to a fissure in the Carboniferous limestones and the erosion of the little

stream that passes through it. The strata appear to incline each way from the gorge as a sort of axis. There is considerable irregularity in the height of the hills on either side of the cañon, but they vary from 800 to 2,000 feet. Some of the highest points have banks of snow all the year. The inclination of the strata of limestone varies from 8° to 20°. The greatest dip is at the entrance of the gorge, and as we ascend, it diminishes until it is uniformly about 6° to 10°. One group of strata near the entrance of the cañon is 35°. Some fragments seem to have broken off of the main ridges, and appear to incline west toward the valley, giving to the section the appearance of an anticlinal. This cañon forms an extremely interesting cross-section of the Carboniferous limestones, and reveals their massiveness and enormous thickness. They cannot be less than 5,000 feet in thickness. The rock is quite hard, brittle, of a bluish-gray color, and in some layers full of seams and cavities of calcite. A fine stream, about thirty yards wide and an average of 2 or 3 feet in depth, rushes foaming down over the immense masses of rock which have fallen from the mountain-sides into its channel. The local drift is here a conspicuous feature also. It is composed of rounded bowlders, with clays and marls reaching a thickness of 100 to 150 feet in regular and horizontal strata, attached to the sides of the gorge, and showing that, however turbulent the waters, the materials were deposited in a lake. At the entrance of the cañon are some remarkable terraces, composed of sands, clays, marls, and rounded bowlders. The high limestone ridges which bound Cache Valley on the east extend far south of Logan, and immediately at the base are a number of prosperous Mormon towns, as Hiram, Paradise, and others. The trend is somewhat to the east of south, and is composed almost entirely of limestones of Carboniferous age. North of Logan to Smithfield, a distance of about ten miles, the quartzites, with variegated sandstones and clays, appear beneath the limestones. Owing to the change in the character of the rocky strata, the symmetry of the range is lost to some extent. The ranges of hills, or of mountains, as they might be called, which bound the west side of Cache Valley, seem to be composed of the same kind of rocks, limestones, and quartzites, for the most part, with partings of clay at times. This range separates the two valleys—Malade Valley from Cache Valley. I was not able to make a minute examination of the whole country, including Promontory Mountain, extending far northward, which is occupied by quartzites and limestones which are, probably, mostly of Carboniferous age. From Corinne to Monument Point, along the Central Pacific Railroad, none but dark, slate-colored limestones can be seen. It would appear, therefore, that a large portion of Utah is made up of these nearly parallel ranges of mountains, trending nearly north and south, with intervening valleys of greater or less width, which, after their elevation, formed shore-lines for detached lakes or bays. So far as the evidence goes, it would appear that the last lake period of this portion of the West commenced in the Pliocene epoch and continued on up to the present time; that the waters once filled all these valleys, so that they rested high upon the sides of the mountains, depositing the sediments of the Salt Lake group, gradually passing into the Post-Pliocene deposits which verge upon our present period. It is quite possible that there have been oscillations of level in these modern lake-waters; but so far as the proofs go, this great inland lake may have continued quite uniform until the Terrace epoch, and that then the waters gradually receded to their present position. If these statements are true, and I believe they are, this country is invested with a charming interest to the geologist.

The story of the changes which have occurred in the geological history of this great interior basin can, no doubt, be traced by uniting link to link the internal evidence of the rocky strata from the earliest period to the present time, and this work belongs to the province of the geologist. To contribute something toward the task of reconstructing the physical geography of this country in past geological times is my principal object in writing out the geological features of our route in so great detail. There is so much similarity in the general structure of the country that I might express the more prominent points in few words, but this would fail to give definiteness to the work. At the risk of repetition, I shall present the principal facts observed during each day's travel in the order in which they were obtained.

As we proceed northward the hills on the east side of the valley become more irregular and broken. Massive beds of the limestone can be seen as far as the eye can reach, capping the summits, and inclining from the valley eastward at various angles, but the lower hills in front are much rounded and covered with grass, showing the softer character of the underlying rocks. Clays, sands, and quartzites of various textures prevail. On the west side the nucleus of the mountains is undoubtedly the same; but high up on the summits, as well as on the sides, are found the yellowish and whitish marls and sandstones of the later Tertiary or lake deposits, filling up, to some extent, the inequalities of the surface, and sometimes inclining, at a moderate angle, in the same direction with the older rocks beneath; with the latter, however, the former do not conform. This range of mountains, which continues uninterruptedly nearly to Marsh Valley, on the west side of Round Valley, rises 1,000 to 1,200 feet above the bed of Bear River. The summits are covered with bowlders, mostly quartzites. The outline of this range is formed of an irregular series of cones, with a general dip to the east. The inclination is quite irregular, sometimes 10°, then 60° or 70°. There is so much material of a soft nature that yields readily to atmospheric influences that the underlying harder strata are much concealed, so that I found it impossible to obtain a continuous section. The mountains on the west side from the crossing of Bear River to Bridgeport present a very abrupt front toward the valley. Originally the quartzites, clays, and limestones were elevated so as to correspond with the ridges or hills on the east side, inclining in the same direction, but the outburst of igneous rocks has produced some changes in position since the elevation of the older rocks. The igneous rocks have the peculiar somber hue and abruptness of basalts, and, in this case, they would appear to have been thrown up under great pressure, so that they are exceedingly compact and massive on the surface, and even where the little streams have flowed down the sides, forming deep cañons, the same close texture is shown. Wherever the sedimentary beds come in contact with these basalts, they are changed more or less. The clays are changed into bluish slates, the quartzites are more crystalline, and the limestones are more or less metamorphic, and exhibit a darker hue. They are also full of cavities, lined with quartz crystals, or calcite, and seams of quartz. In this range of hills or mountains, near Bridgeport, silver mines have been found. One lode has been discovered that yielded ore which is said to assay $75 per ton. It is not probable that this will ever be a successful mining district, and however rich the ore may be in localities, it will doubtless be found only in pockets, and not in regular lodes. The area is limited, and whatever ore there may be, it has probably been segregated in fissures or cavities by the action of the basalts on the contiguous quartzites. Originally the quartzites and lime-

stones inclined at a high angle eastward, and gave to the west side of the range of hills a slope like the steep roof of a house, but the elevations of the basalts, which occur mostly on the east side, carried the stratified beds up toward the summit of the ridge in such a way that a sort of local synclinal was formed. The abruptness of the sides of this range of hills, and the dark color of the massive basalts, with the variegated color of the changed and unchanged rocks, which send the ridge-like cones up 1,000 to 1,200 feet above the valley, give a remarkably rugged, picturesque character to the scenery. The valley at the base is a meadow in the luxuriance of its vegetation. It is divided up into farming lands and meadows, and the numerous little streams which gash deeply the sides of the mountains and flow down the steep foot-hills can be easily guided all over the fertile valley.

The immediate valley of Bear River, near the crossing, is somewhat interesting on account of the fine development of the lake deposit. It is here composed of clay, sand, and marl, yellow and rusty-drab color, and attains a thickness of 200 to 300 feet. The elevation of Bear River Valley at the bridge is 4,542.5 feet, and the highest terrace on the east side 4,737.7 feet, and the highest on the west 4,779.3 feet. The immediate valley of Bear River may be said to have been worn out of the Pliocene or lake deposit. Looking southward along the eastern side of Cache Valley, the Tertiary beds can be distinctly seen, jutting up against the sides of the mountains, and literally filling up the low places in the range. Looking northward the same beds seem to jut up against the hills, but the river appears to cut narrow, gorge-like channels through several of the parallel ranges of hills or mountains. From time to time we find heavy beds of conglomerates resting upon the finer sediments of the lake deposit, the exact age of which is obscure, though probably formed just prior to the present order of things.

Before leaving this beautiful valley we may say a word about its agricultural resources. It is about 7 miles wide, and 60 in length from north to south. It was a matter of great surprise to all my party to find these mountain valleys filled up with inhabitants, and the land under a high state of cultivation. In Cache Valley there are at least ten thousand people at this time industriously cultivating the soil, with all the appliances of comfort around them. Whenever this country escapes the ravages of the destructive grasshopper the crops are abundant. On either side of the valley great numbers of little streams, after cutting deep gorges into the mountains, flow down into the plains, and are guided by the farmer all over his lands. There is no cultivation without irrigation, and with it, crops of all kinds are most excellent. The average elevation is only between 4,000 and 5,000 feet. We leave the valley, on our journey by way of Red Rock Pass, which is formed of a group of Carboniferous limestones, a portion of which have a reddish appearance in the distance, from the presence of oxide of iron. The small stream, which constitutes the drainage of the upper or north edge of the valley, has, at some points, cut a narrow channel through what may have been a sort of anticlinal fissure, for the strata of limestone incline each way from the opening or pass, 10° to 20°. These masses of limestone all point to a period of great erosion, and are monuments to indicate the huge and extensive thickness of the limestone strata in this region. East Red Rock is 300 feet from summit to base. The divide between the drainage of Bear River and that of Port Neuf, which flows into Snake River, is 5,041.9 feet in elevation. From Red Rock Pass we travel down Marsh Valley, with high hills and some quite lofty peaks on either side, composed of the same quartzites and limestones that we have before

noted. The valley is about ten miles wide and is entirely occupied with the Pliocene beds from side to side. The terraces underlaid by this deposit are a marked feature, and rise 300 feet above the creek, the middle one 150 feet and the lowest 50 feet. The hills on the west side are lower and less rugged, rising 400 to 1,000 feet above the valley; but on the east side they are more formidable, 1,500 to 1,800 feet in height. The surface outlines are quite rounded and smooth by weathering, so that the strata are not well defined. Marsh Valley, which is about five miles in length, is like a meadow covered with tall, thick grass. Soon after passing the divide, a small stream commences running northward toward the Port Neuf, and on either side are wide, swampy, or springy belts, contributing springs at every step, and in a distance of ten miles it becomes a good-sized river. The luxuriance of the vegetation is a marked feature. The entire channel was filled with several species of water-plants, *Potamogeton*, *Ranunculus*, *Brasenia*, *Myriophyllum*, and many others. As a necessary result, the fresh-water molluscous life was most abundant, *Planorbis*, *Limnea*, *Physa*, &c.

About ten miles north of Carpenter's Station we come to the southern border of the great basaltic overflow in the valley of Port Neuf and Snake River, for I am now convinced that this comparatively modern eruption of igneous material covered an immense area of country, and might be called the basin of a wide, extended lake of igneous material, of which the Snake-River Basin was the center. Whether the melted material flowed up the valleys of the streams that empty into the Snake River, or issued from fissures extending up these valleys and overflowing them from side to side, it is difficult to determine. The latter explanation is most probably the true one, judging from the uniformity in thickness and extent of this vast sheet of lava. The elevation of our camp on the south border of the lava basin in Port Neuf Valley is 4,625.5 feet, and this seems to have been the height to which it reached in its overflow. The little streams have cut new channels directly through the lava flooring, and thus excellent sections of it may be studied. As a rule the streams flow along deep muddy channels, with boggy border and abrupt sides obstructing and even rendering the fording of them dangerous; and on either side, varying in distance from a few yards to a half a mile, is a vertical wall of basalt, which, in the distance, has a partially columnar appearance. The basalt fractures into vertical masses that have an obscure five or six sided form. Sometimes these walls are so steep and uniform for miles that they cannot be scaled, and some broken-down, eroded portion must be sought for before the traveler can escape from the marshy channel of the streams to the table-like plateau above. The lower portion of this lava floor is very compact and massive, but the top part is more or less vesicular. There is very little, if any, of the usual spongy lava; it is all very heavy, even though full of cavities. It effervesces freely, showing the presence of lime in considerable quantities. The illustrations of exfoliation are abundant everywhere. Sometimes quite thick beds show an exposed surface of rounded masses, decomposing in concentric layers as if it was an aggregation of large concretions. The disintegration of these igneous rocks is mostly accomplished through the process of exfoliation. The general appearance of this table-shaped belt of basalt contrasts strangely with the ranges of hills on either side. On the east side of the valley the foot-hills are quite irregular, high, and covered with drift. On the west side they slope rather gently down to the river, deeply cut here and there by ravines. The superficial deposits extend high up, 500 feet or more above the bed of the river, lapping smoothly on the basis rocks. The white Pliocene sandstones are exposed at one locality not

far below the toll-gate. The Port Neuf River is full of little falls or rapids 3 to 6 feet high, where the water flows over the basaltic floor, adding much to the attractive beauty of the scenery. Here and there we find outcroppings of cherty and silicious limestones underlaid by shales. Isolated hills or ridges composed of these rocks are revealed by the river, sometimes extending partly across the valley, remnants left from former erosions. At the bend of Port Neuf a pretty little stream about 10 feet wide flows in from the northeast. On the west side the rusty-gray quartzites are well shown, inclining 55°. In passing down the Port Neuf from the bend, we have the yellowish-gray quartzites just mentioned, then dull purplish quartzite, composed largely of an aggregate of quartz pebbles, then dark purplish drab slates. The latter seem to form the central portion of a local anticlinal. The reverse dip extends only a short distance, while the original dip, a little north of east, is restored, and this continues for five or six miles, the strata consisting of alternate beds of quartzites, slates, limestones, &c., inclining 15° to 50°. In this series are three beds of impure cherty limestones. The quartzites possess a great variety of texture and color, from a dirty, rusty brown or rusty yellow to a fine grayish quartz. The reddish or purplish quartzite is very thick, and forms most beautiful pudding-stones, very seldom a coarse conglomerate. At the lower end of Port Neuf Cañon, just before it opens into the plain, there is a high ridge, rising 1,500 to 2,000 feet above the river, which seems to form the central mass of the general anticlinal, for the strata dip each way from it. This ridge, as it extends off far southward, shows the slopes or inclinations of the beds well. The Port Neuf, after making the bend near Robber's Roost City, cuts a channel through the ridges nearly at right angles for five or six miles, exposing at least 10,000 feet of quartzite. The ridges run quite regularly north and south, and the principal ones are very persistent, while connected with them are some fragmentary ones. The age of this vast series of stratified rocks is quite obscure, and may continue so. The limestones which contain the well-defined Carboniferous fossils mark a horizon which takes in a considerable thickness, but below this horizon there is a group of strata of variable thickness, as well as texture, that is not likely to reveal the proofs of its age. It is true that there is ample room for several times as great a thickness of strata in the Devonian and Silurian, and even extending down into the sub-Silurian, where, perhaps, some of the metamorphic quartzites should be placed. In this report I shall merely state the facts as I have been able to observe them, and await the results of future explorations to clear up any obscurities. In this great country the formations are usually so widely extended geographically that the discovery of proofs of their age at any one locality may unravel the obscurities of years of labor. Limestones of undoubted Carboniferous age occur everywhere, and, as a rule, cover the summits and flanks of the highest ranges of hills or mountains. In many instances the great thickness of these limestones and the slowness with which they yield to atmospheric influences have prevented many of the ranges from being much rounded, and perhaps removed entirely. Over a great portion of Utah, extending northward into Idaho and Montana, the Carboniferous limestones form the great protecting covering to the mountain ranges. The erosion of the basalt in the Port Neuf Cañon is a feature of some interest. Sometimes for miles it has been entirely removed; then it will re-appear in full force. Remnants are sometimes seen on the sides of the cañon, showing that the waters at a modern period have worn wide channels through. In some instances there are evidences of two great periods of outflow of melted material, forming horizontal belts, as it were. At one locality this fea-

ture is well shown where the river has cut through the basalt, revealing 150 feet in thickness, with the floor or terraces; the lower one is the immediate channel of the river, and the other forming distinct walls on either side, with an obscure columnar fracture. I am inclined to believe that there were at least two important periods of overflow of basalt all over this region, although in a geological sense they are connected together. After leaving Port Neuf Cañon we come out into the broad plains bordering on Snake River; on either side, as we continue northward to Ross's Fork, we find the hills of various heights and composed of a variety of quartzites, with some limestones. They are much rounded, and covered with a heavy deposit of *débris* or kind of drift, and the whitish and gray sandstones and the yellow and drab marl of the Pliocene fill up the irregularities of the surface, and sometimes incline at a small angle, as if they had participated in some of the later movements that elevated the country to its present position. From the stage station on Ross's Fork to the present location of Fort Hall is about 16 miles. The valley is a beautiful one, and was originally called Warm Spring Valley, from some warm springs that form the sources of the little streams that flow through it, but it has since received the patriotic name of Lincoln Valley. Among the lower ranges of hills that border the east side of the great Snake River basin, especially from Port Neuf Cañon northward, the Pliocene deposits are well shown, and lie beneath the basaltic floor. In the Port Neuf Cañon this fact is illustrated by the wearing away of the cap or floor of basalt in a number of localities, but on the sides of the hills this is shown with equal clearness by the elevations of the basalt. The dip of the beds is not great, usually not more than 5° or 10°, and in all cases in the direction of the great basin. This would indicate that there had been a moderate elevation of the mountain ranges or a depression of the basin at a very modern date, even approaching very close to our present period. The effusion of such a vast amount of igneous matter from the interior of the earth might suggest the possibility, or even probability, that the cause of the subsequent changes in the hills, around the borders, was either contemporaneous or subsequent to the effusion of the melted material. If the elevation began with the eruption, it certainly continued long after it ceased, inasmuch as the basalt is lifted up in thick beds, at the same angle with the underlying strata. Not only in the valley of the Port Neuf and Snake River is the basalt found in conjunction with the lake deposits, but in numerous localities all over the Northwest, it seems to rest upon these Pliocene beds, readily adapting itself by the form of the under surface to the irregularities of the surface of the lake deposits.

A few words in regard to the geological character of the hills bordering Lincoln Valley, around Fort Hall, may not be without interest in this connection. In ascending a small gorge-like valley east of the fort, where the waters have excavated a channel directly through the different beds, we have excellent opportunities for studying such of them as are developed in this region. There is a general dip to the strata that may be regarded as uniform and in one direction, but the local disturbances are, oftentimes, very complicated, and in many cases formations which are really well developed are entirely concealed over large areas, or simply crop out here and there over very restricted areas. The mountain ranges all over the West are full of cañons and valleys, cuts or gashes, from the axes or central portions to the plains. These vary so much in character, owing to the intensity of the erosive force, that some of them may penetrate the very core of the mountain, and cut through all the strata on the sides into the plains, or it may be more or less shal-

low, or so hard, and the strata so covered with grass or *débris*, that they elude the scrutiny of the geologist. By exploring with much care large numbers of these natural cuts, a very true conception of the geological structure of a mountain range may be obtained. It is usually quite difficult to measure the thickness of the beds; indeed, it is impossible; and we must therefore rely upon a judicious estimate, aided by good barometrical observations. Neither are exact instrumental measurements of strata of great importance in this country. Take, for example, the limestones of the Carboniferous age; they vary in thickness in different localities, all the way from a few hundred feet to as many thousands, and yet they being sea-formed rocks, are supposed to tend toward uniformity of thickness. In this narrow valley we find that the Pliocene beds which form the foot-hills of all the ranges of mountains surrounding the great Snake-River Basin are also under the great basalt floor. These beds sometimes are found 400 or 500 feet above the level of the plains, and so conceal the underlying rocks, upon which they repose unconformably, that it is difficult to unravel their connections. Then there is a thickness of several hundred feet of grayish-brown limestones, more or less arenaceous, with intercalated layers of clay or limestone, and full of Jurassic fossils. Underneath is a group of sandstones, varying in color from a dark to a light brick-red, resembling the sandstones so well shown in Weber Cañon, and probably of the same age, but entirely destitute of organic remains. This group is 300 to 500 feet thick, and inclines 15° to 25°; underlying the red sandstones are limestones, which are undoubtedly Carboniferous, and beneath them quartzites, sandstones, pudding-stones, conglomerates, of unknown age. The group thus enumerated forms the mass or bulk of the regularly stratified rocks, composing the ranges around this great basin.

Before closing this chapter, I may enumerate some of the elevations along our route, for the purpose of showing the relative heights of the hills surrounding the plains and valleys, as well as to indicate one of the important conditions for successful agriculture. There seems to be no want of fertility in the soil of our western plains, and when the two most important conditions are favorable, climate and moisture, or water for the purposes of irrigation, then agriculture will be a success. However abundant the water may be, either in the form of rain or in streams for irrigation, if the elevation is 7,000 feet and upward, the climate is liable to be too severe and uncertain for settlement. From barometrical observations along the route of travel we found that the elevation of our camp on Ross's Fork was 4,394 feet above the sea; on the divide toward Fort Hall, 5,072 feet; Fort Hall, 4,724. These figures will serve to indicate the general elevation of the plains and the immediate foot-hills, and they show that the climate need not be more unfavorable for agriculture than that of Salt Lake Valley, in which the Mormons have been so successful. How far the excessive dryness of the atmosphere may be an obstacle it is hardly possible to decide. The past season was an unusually dry one. The difference between the wet and dry bulb in June on the Snake River plains was 35°, which indicates an unusual freedom from moisture in the air. The broad bottoms in the immediate vicinity of Snake River are at a somewhat lower level, and can be made very productive; large quantities of hay are prepared every season. Inasmuch as an Indian reservation has been made on Ross Fork, we may have some experiments in agriculture on these plains in a short time.

CHAPTER II.

FROM FORT HALL, IDAHO, TO FORT ELLIS, MONTANA.

We will not take our leave of Fort Hall without a word of thanks to the officers of that post for their hospitable courtesy to us. We remained in this beautiful locality, a real oasis it might be called, two days, resting our animals and laying in supplies and making repairs. Every facility that could possibly be provided for us, was granted by Captain J. E. Putnam, the officer in command, as well as by Lieutenant Wilson, commissary and quartermaster. The manner in which Captain Putnam extended the courtesies of the post to all my party was even more grateful than the material afforded. The assistance we obtained here advanced our explorations several days of time. Fort Hall is a small but exceedingly neat post, which was constructed by the officer at present in command about one year ago, and is located in a beautiful, fertile, grassy valley, among the foot-hills on the east side of the Snake River Basin, about forty miles east of the old Fort Hall. Numerous streams of pure water have been conveyed, by artificial channels, all through and around the grounds, so that, in the dry season, when the vegetation of the surrounding country is parched by the sun's rays, it is here as fresh and green as in spring-time. During the winter, the waters coming from Warm Springs, about two miles above the post, never freeze over, and the whole valley is protected from the cold winds by the surrounding hills, so that I do not hesitate to regard it as one of the most desirable spots in Idaho. No finer locality for a military post could have been selected in this region.

In the afternoon of June 23, we left this pleasant resting-place and the kind hospitality of its officers with reluctance, and made our camp on Blackfoot Fork, about seven miles to the northward. This is a pretty stream about 30 feet wide, and 6 to 8 feet deep, taking its rise near Soda Springs, and draining a large area. All through the valleys of the main stream and its branches, are the results of the basaltic overflow, and in its passage through the mountains it has carved out a deep cañon through basalts, limestones, and quartzites. After leaving the mountains it flows across the plains with a swift current, about thirty miles, over a floor of basalt, to the Snake River. From Fort Hall the road winds among low hills, underlaid by the light-gray marls and sands of the Pliocene, with some quite high ridges or hills of blown sand. In some instances the loose sand is so deep as to impede traveling. The bottoms of Blackfoot Creek are quite sandy, and the vast quantities of fresh-water shells scattered about formed a noticeable feature, and indicated an excess of molluscous life.

On the morning of the 24th I followed up the south side of Blackfoot Creek to the mouth of the cañon. The lower hills are covered with igneous rocks. The higher ridges have a trend about northwest and south-east, and appear to form irregular anticlinals. Sometimes a cap of basalt will lap, roof-like, on to the ends of these ridges as they extend down to the plains. This bed of basalt inclines more or less, on the sides of the ridges, but gradually becomes horizontal in the plains. A careful examination of one of the ridges showed it to be composed of quartzites, inclining northeast at a high angle, with the external somber steel-gray hue that strata of all ages seem to have when affected by contact with the igneous rocks in their outflow. Over the quartzites, and conforming to them, are strata of Carboniferous limestones. At the point where

the Blackfoot Creek emerges into the plains, the basaltic walls on either side are 50 to 60 feet high, and higher up the cañon the channel passes through ridges of limestone and quartzite at right angles, 1,000 to 1,500 feet above the plain.

From Blackfoot Creek we traveled over a nearly dead level to Taylor's Bridge, the crossing of Snake River, eighteen miles distant. Far distant to the west the three *buttes* can be distinctly seen, like isolated fragments of mountains in the plains; still further to the west can be seen, on a clear day, the dim outlines of the Salmon River Ranges. To the east are a series of broken or irregular ranges, with low grassy foot-hills in front, usually rising 1,000 to 1,500 feet above the plains, but with here and there a high peak, 2,000 to 2,500 feet in height, covered with snow. That this basaltic outflow occurred at a time when this vast basin was occupied by the waters of a lake, I believe, from the fact that all the lower portion is exceedingly compact and heavy in its texture, and the surface, though sometimes full of cavities, must have cooled under a moderate pressure of water at least. After this basalt ceased to flow the lake continued on, so that a superficial deposit of sand and fine volcanic dust, varying from 10 to 50 feet, covered the great basaltic cap. During the dry season of summer this volcanic dust becomes a sort of impalpable powder, filling the air with clouds to such an extent as almost to suffocate man and beast.

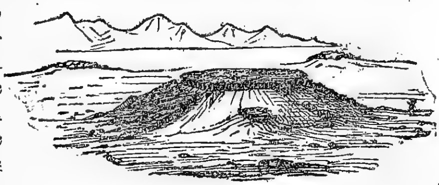
At Taylor's Bridge the waters of Snake River rush with great velocity through the narrow gorge-like channel which they have worn out of the basaltic floor. The walls on either side form excellent sections, and in the autumn, when the river is low, expose 100 feet or more of the basalt, with all the varieties of texture. These walls show an irregular columnar structure or jointage, and the decomposition or erosion is greatly aided by this condition. The different layers show clearly the different periods of effusion, and in some instances the lowest portions indicate that, after the great mass had cooled and become solid, fluid basalt had been thrust up, showing a texture and color much like modern lava, only more compact. But the most interesting feature in this locality is the existence of numerous cavities, worn into the solid basalt, which are usually called "pot-holes." These "pot-holes" occur by thousands on both sides of the river, for miles up and down, varying in diameter from a few inches to several feet. They are very distinct on the walls of the river-channel, where the latter seem to have been split down from top to bottom. Many of them have in them, even at this time, the rounded masses, which by constant agitation of the waters have worn out the cavities. Some of these holes are 2 to 3 feet deep, although not more than 4 to 6 inches in diameter. The examples of degradation by exfoliation are finely exhibited here, so that the basalt itself would seem to have assumed aspheroidal shape in cooling, and is now falling in pieces by concentric layers.

From Taylor's Bridge we traveled along the west side of the river to Market Lake, a distance of twenty miles. To the east of our camp, near the entrance of Henry's Fork, are two rather high flat-topped basaltic *buttes*, which have the appearance of extinct craters. Their summits are 600 to 800 feet above the plains around them. The rim of the south *butte* is much broken down. They were, undoubtedly, centers of effusion for the lava. Far in the distance, seventy or eighty miles a little south of east, the Tetons loom up grandly, with the form of shark's teeth. To the north of them, and quite distinctly visible, is Mount Madison, one of the finest peaks in the northern ranges of the Rocky Mountains. To the west of Market Lake

are some moderately high basaltic ridges, the highest portion of which has received the name of Kettletop Butte. Market Lake is a kind of sink, probably produced by the spring overflow of Snake River, and is entirely dry the greater portion of the year.

On the morning of June 26, I started eastward from Market Station toward the *buttes*, near the bend of Snake River. The road wound along low basaltic hills, which really form a marked feature over a large portion of this basin. At the present time the surface is perfectly dry, but at some period in the past little streams circulated all over the surface, wearing out their valleys through the basaltic crust, leaving portions like broad table-tops, (Fig. 3,) occupying a greater or less area. From beneath these fragments of the crust, the loose sands have been washed out all around, so that the overlapping edges have fallen down in every direction, from a common center in many instances.

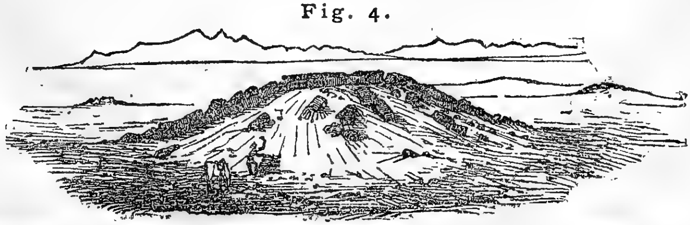
Fig. 3.



BASALT TABLES, SNAKE RIVER BASIN.

It would appear that these hills show that there were several periods of overflow of basalt, that beneath the sand is another floor, and upon this was deposited at the bottom of a lake a thickness of several feet of sand before the upper floor of basalt was formed. The northern portion of the basin is covered with thick beds of sand, into which the wheels of our wagons would sink 2 or 3 feet at times. On Camas Creek are some interesting sand dunes. On the northeast side are some conspicuous hills of blown sand, visible at a distance of twenty to forty miles, which indicate that the direction of the winds is from the southwest. Dry Creek, which in the spring season affords a channel for a large body of water, forms a cañon in the basaltic floor, with walls 50 feet high. In midsummer there is no running water. On this creek there is a stage-station called "Hole in the Wall," which derives its name from a remarkable cave in the basaltic rocks. About a mile west of the station there is a depression in the level plain 30 by 50 feet, where the rocks seem to have sunk, revealing on the north side quite a large opening. This opening or cave connects with others to an indefinite extent, under the great basalt floor. We examined several of these caves, which were connected together only by small openings in the partition walls, each with dimensions of 100 to 200 feet in width and length, and 30 to 50 feet deep. The bottoms of the caverns show unmistakable evidence of having once formed a river-bed. The water still flows at times along the channel. Some person had dug a hole about 10 feet deep, which showed the layers of deposition of sand and clay as perfectly as along the banks of any of our little streams. We see by this illustration (Fig. 4) that underneath this basaltic crust streams of water

Fig. 4.



BASALT FLOOR, UNDERLAID WITH PLIOCENE BEDS.

have worn in the past, and may be now, wearing out their channels toward Snake River, and that this may be only one of numerous examples in this

great basin. We can also see how readily such rivers as Camas, Medicine Lodge, Godins, and many others disappear in the plains, and find their way, from ten to thirty miles, to Snake River, underneath this basaltic floor.

Before leaving this interesting region, I wish to add a few general remarks in regard to what may be very properly called the Snake River Basin. There is here a broad, nearly level plain, from seventy-five to one hundred miles in width, and one hundred and fifty to two hundred miles in length, surrounded on all sides by mountain ranges. This basin follows the course of Snake River, and is really an expansion of the valley; and it at first extends from the northeast to the southwest, bends around west, and then continues northwesterly toward Boise City. The mountains on either side form a series of more or less lofty ranges, some of the more prominent summits rising to a height of 10,000 feet. These ranges appear to the eye, from any one point of view, to trend about north and south, but the trend of the aggregate ranges is plainly a little west of north and east of south. Between these ranges are valleys of greater or less breadth, varying from one to five miles in width, oftentimes of great beauty and fertility, through which wind some of the numerous branches which flow into Snake River. The great basin is entirely covered with a bed of basalt of quite modern date, (Fig. 4,) and this basalt has set to a greater or less distance up the valleys of all these streams. It extends up the Port Neuf Valley twenty or thirty miles. The American Falls are formed by the descent of Snake River over the basalt. I believe that this vast basin has been worn out of the mountain ranges by erosion; that the three *buttes* and other fragments of ranges scattered over the plains serve as monuments in proof of this statement. This basin was also the bed of a lake which probably originated during the Pliocene period. At any rate, I have been unable to discover in the immediate vicinity of this basin any Tertiary beds of older date than the Pliocene; and underneath the basaltic crust there is a considerable thickness of the deposit. The effusion of the basalt was one of the latest events, and must have merged well on to our present period. The average elevation above the sea is from 4,000 to 5,500 feet. Our camp on the Blackfoot Fork was 4,324 feet, which was at least twenty miles above Snake River east; and, inasmuch as the basin extends down Snake River, the valley below the American Falls, and near Boise City, cannot be over 4,000 feet, and may be less, while near the northern rim the elevation is 5,730 feet. From the great basin of Snake River we ascended the hills that form the northern rim over a divide 6,200 feet high, with hills on either side rising 1,200 to 1,500 feet higher. All these hills are capped with beds of basalt, which incline southward toward the basin at various angles, from 5° to 10°. Where the rocks can be seen they are plainly igneous, but as we approach Pleasant Valley the hills are so covered with a drift deposit that it is seldom the underlying rocks can be seen. The surface here, for miles in extent, is made up of short, abrupt hills, generally one main sharp ridge, with a great number of side ridges extending from it. These hills are covered over with grass. The rocks that are scattered thickly over the surface, and enter largely into the composition of these superficial deposits, are rounded bowlders of quartzites mostly. The distance from our camp on Dry Creek, in the Snake Basin, was sixteen and a half miles. The little stream that flows through Pleasant Valley emerges from a cañon, which has nearly vertical walls of basalt, with an irregular bedding, but with jointage quite perfect, fracturing into columnar masses. A vast amount of *debris* has fallen down the sides of the walls and into the bed of the stream. Some of the rock is very

compact in texture; other portions rough, vesicular, much like the basalt in Snake River Basin.

On the morning of June 29, we left the beautiful valley behind us, and, traveling 9 miles north, crossed the water "divide" of the Rocky Mountains. On the west side of the road, for ten or fifteen miles, the rounded, grass-covered hills prevailed, and over the surface, quartzite bowlders, mingled with some sandstones, were scattered thickly everywhere. In the sides of the ravines were numerous bare spots, which revealed a deposit of yellowish-brown sand. There is evidently a very extensive modern deposit all over the belt of country which forms what I will call the water divide—a belt from ten to twenty miles in width, in which the drainage gathers full force on the one side toward the Pacific, and on the other toward the Atlantic. The elevation along the "divide" is 6,480 feet. To the west is a range of mountains reaching up above the limit of vegetation, among the snows. We measured one of the high limestone peaks and found it 9,704 feet; but there were several others still higher farther to the west, which must have been 10,000 feet high. These mountains are concealed high up around their sides with the drift deposit mentioned above, so that their examination is rendered quite difficult. The mountains, so far as we could examine them, seem to be composed of a great thickness of carboniferous limestones, capped with quartzite and quartzitic sandstones. The first range has four prominent cones, with several smaller ones, thewhole having a general trend about north and south, with an inclination to the west 25°. On the east side of the road were high, ridge-like hills, capped with basalt, all inclining to a moderate angle southward toward Snake River. Wherever any of the branches of Dry Creek cut through the grass-covered hills, or ridges, cañons are formed with vertical basaltic walls. This igneous rock seems to be very homogeneous in composition, except that some portions may be more compact in texture than others. The surface of the whole country is exceedingly picturesque, diversified by lawn, terrace, ridge, and rounded *butte*, with most beautiful grassy ravines. Where the drift deposits are not too uniform and thick, we find exposed here and there outcroppings of a yellowish calcareous sandstone, which is probably of the age of the lignite beds of the West. No indications of coal were observed, but leaves of deciduous trees, like those found in the vicinity of the coal-beds in other places, were found here. These sandstones form long ridges, inclining east about 10°. The rock is more or less firm and compact; some of it is a greenish quartzite. Here and there, on the summits of the ridges, are beds of basalt, showing igneous outflow at a modern date. Indeed these basaltic caps on the hills have presented many connected sections for examination which would otherwise have been obscure, and fragmentary from erosion. Far to the west may be seen range after range of mountains running nearly north and south; as they extend down into Snake Basin they seem to run out into the plain, so as to present an *echelon* appearance. The ranges, so far as we can see, are the eastern portions of some great central axis, which may be the Salmon River Range. I have not been able to extend my observations so far west; but the ridges, so far as I could examine them, of which there were a number extending over a belt of fifty miles in width, appear to incline eastward. The abrupt sides of the west, the sloping sides on the east, the force as well as the material which have modified and given form to the surface, must have come from the west, inasmuch as on the western or abrupt sides of the mountains and hills there is the greatest accumulation of drift-bowlders. The loftiest portions of the ranges seem to have

been elevated through the more modern formations. The high group of mountain peaks to the southwest of Junction Station are composed mostly of Carboniferous limestones and quartzites. The series of rocks as exposed here may be arranged in ascending order as follows: First. A series of reddish, yellow and brown calcareous shales. Secondly. Limestones, the upper portion of which is a coarse conglomerate, made up mostly of water-worn masses of limestones, with abundant fossils, *Spirifer*, *Productus*, Corals, Crinoid stems, with *Athyris subtileta*. Thirdly. Capping the mountain is a quartzose sandstone light-gray or weathering to a dark-brown, with a reddish tinge. In the valley of a little creek that cuts the hills on the north side of the road near Junction Station, I endeavored to ascertain the character of the formations as far as they were exposed. Commencing at the base, we find a yellow arenaceous clay, passing up into a yellow sandstone, rather friable, sometimes quite fine-grained; again a sort of pudding-stone or pebbly conglomerate. 50 to 100 feet above is a curious conglomerate made up mostly of water-worn masses of Carboniferous limestone, varying in size from the fraction of an inch to several inches in diameter. The thickness of the entire group of rock I estimate at from 1,500 to 2,000 feet. Still further to the northward are rounded grassy hills composed of softer beds with a reddish tinge, passing gradually into brick-red beds, which may be Jurassic or Triassic. Red Rock Valley is very beautiful to the eye. The stream is about twenty yards wide, with a narrow valley, north of the junction, but toward its source it expands out to a width of ten miles, forming a splendid upland meadow. This valley extends up twenty-five miles, with an average of ten miles in width. On the north side of this stream there is a high and quite picturesque ridge, composed wholly of the red beds, with perhaps some gray Jurassic rocks on the summit. The dip is plainly northeast, and varies from 15° to 30°. Toward the source of Red Rock Creek, a high ridge on the south side of the valley reveals the rocks well, inclining southeast 10° to 15°. This ridge seems to have been influenced by a distant range, which has raised the beds lower down on the creek. The limestones and thick group of beds above, extend off in detached ridges, like steps, toward the river of Snake Basin. One of the most singular features of this region is the immense thickness of coarse conglomerate, apparently forming a portion of the Carboniferous series. These conglomerates appear to be local, and occur nowhere else, so far as my observations have extended. In the high peak near Junction Station the beds are well shown from the oldest exposed in this region. The Carboniferous rocks lie at the base, and gradually pass up into the conglomerates, with no want of conformability. In this mountain an immense thickness of rock seems to have been lifted up vertically, so that at an elevation of 9,000 feet they are nearly horizontal, while on one side the beds lapped down so as to be nearly vertical. On the summits is a great thickness of quartzites. The conglomerates seem to have been formed of pre-existing Carboniferous limestones almost entirely. The cement is calcareous in some instances, itself a limestone of fine texture, and the masses of limestone and other rocks inclosed have been very much rolled in waters. How great an area this conglomerate occupies I did not determine, but it is evidently not large, probably not over fifty or one hundred square miles. Far to the eastward, seventy to eighty miles distant, the Tetons are distinctly visible. For a hundred and fifty miles west of these mountains are many ranges of hills, some of them rising to the dignity of lofty mountains, between 10,000 and 11,000 feet above the sea, with no rocks older than Carboniferous exposed. For one hundred to one hundred and fifty miles along the

Rocky Mountain "divide" the series of rocks exposed may be summed up as Carboniferous, Red beds, Jurassic probably, some Cretaceous, with patches here and there of Eocene, or Upper Cretaceous, containing impressions of deciduous leaves. Igneous rocks have also been thrust up through them all and spread over the summit. These have shared in the later movement to such an extent as to incline at moderate angles.

About two miles below the Junction Station, on the south side of Red Rock Creek, there is a great exposure of the Carboniferous conglomerates, dipping 21° a little west of south. The creek here passes through a close monoclinal interval for half a mile, and then opens out into Rock Creek Valley, with two high ridges, with yellow and red beds (Jurassic) at their base. Red Rock Creek forms one of the head branches of the Jefferson Fork of the Missouri, and rises in the "divide." It receives its name from the numerous exposures of the brick-red sandstones (Jurassic) and Cretaceous clays along the banks. Along the streams are terraces more or less well defined, of various heights, showing the water-line. About five miles north of the Junction we find the Pliocene beds, filling up the valleys of the streams, sometimes reaching a thickness of several hundred feet. The greater portion of this deposit is a light-gray marl, with concretionary masses, and a sort of pudding-stone. In these concretions are often inclosed masses of the basalt, which occur here and there all over the country. While we have the evidence of a period of effusion subsequent to the deposition of these lake-beds, from the fact that the basalt lies over them, we see by these inclosed masses, frequently, that there were other periods, either before or during the Pliocene. At one locality I found in these lake-deposits the fossil remains of a species of *Anchitherum*, and a land-snail, *Helix*. The inclination of these modern beds is west 5°. In passing over the divide from Red Rock Creek to Black-tailed Deer Creek, and from the highest point, 7,044 feet, we could look back on a large extent of country drained by the different branches of these streams.

This broad valley, like most of those in the west, was formed by erosion, and has been filled up with lakes, at the bottoms of which were deposited 500 to 1,000 feet of marls and sandy clays, during the later Tertiary period. Here and there, these deposits have been stripped away, showing remnants of old granite ridges, which either fill up the valleys, through the walls of which the streams make their way, or they are exposed as remnants of larger ridges, which extended originally across the valley. Some of these modern beds have a light brick-red appearance, somewhat resembling the Jurassic group. Reaching the drainage of Black-tailed Deer Creek, we find an immense development of the gneissic strata, inclining about west 30° to 45°, and extending about eight miles. There are alternate beds of quartzites, true gneiss, mica schist, the quartzites largely predominating. There are also thick seams of white quartz. Large portions of the area occupied by the metamorphic rocks are concealed by the outpouring of basalt. The metamorphic beds are here separated from the Pliocene deposits by a deep ravine or dry valley, the sides of the former having a regular slope, and indicate a sort of shore-line for this lake. Here and there we find curious local anticlinals in the metamorphic strata, caused by the elevation during the effusion of the basalt. On the west side of Wild Cat Cañon, through which the road passes to Black-tailed Deer Creek, the mountains rise to a height of 8,500 feet, and over a large area are groups of the harder feldspathic quartzites, which have resisted erosion, and now remain like old ruins, and present a very picturesque appearance. These quartzites,

by their jointage and style of weathering, present some admirable rock studies, (Fig. 5.)

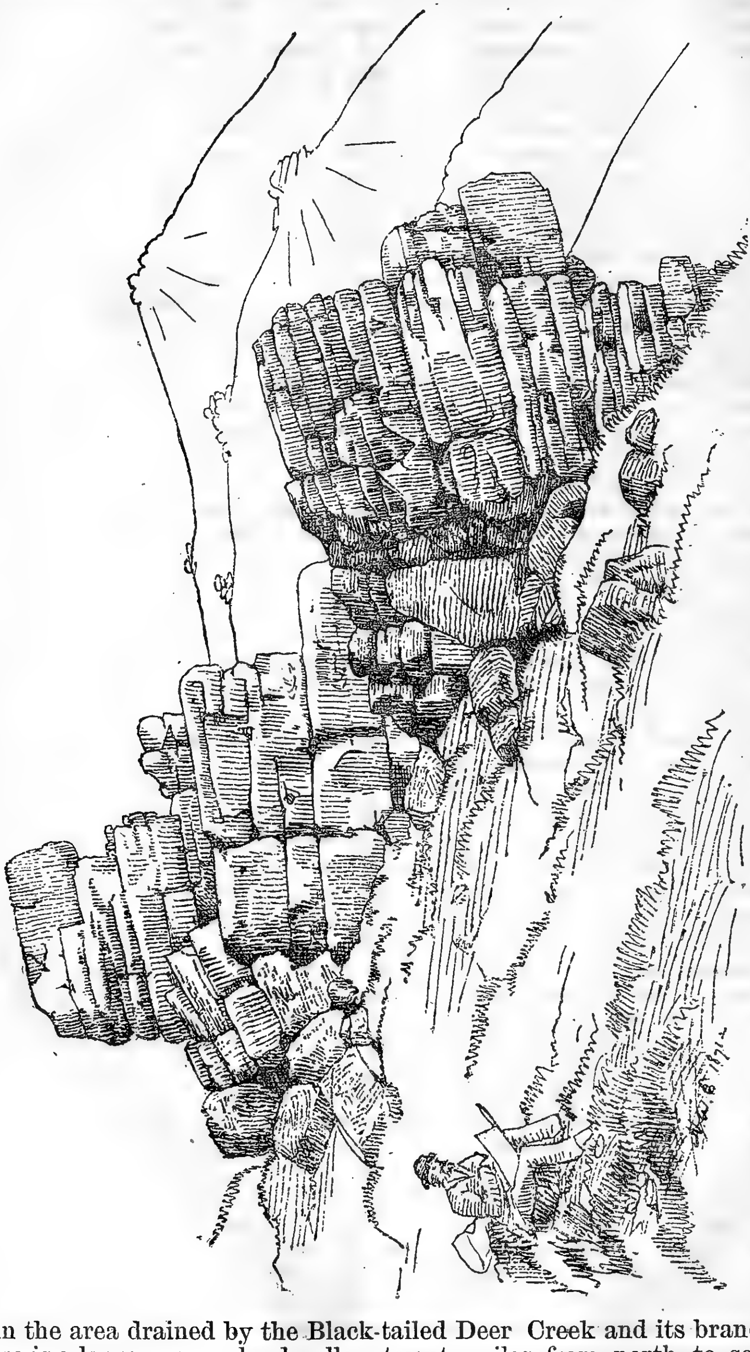


Fig. 5.

REDDISH FELDSPATHIC GRANITES, WEATHERED OUT ON MOUNTAIN TOPS, AT WILD CAT CANON.

In the area drained by the Black-tailed Deer Creek and its branches there is a large open upland valley, twenty miles from north to south,

and thirty miles from east to west, underlaid by the Pliocene deposits, inclining gently northwest, influenced probably by the Black-tailed Deer Range.

The country about these sources or branches of the Jefferson fork is very fine, and appears most attractive to the eye, with a fertile soil, excellent water, and well adapted for settlement, except that the winters must be very severe. The elevation of the valleys is from 6,000 to 7,000 feet, involving early and late frosts, and deep winter snows. About a mile before Wild Cat Cañon opens into the valley, the variegated porphyries commence, a dull purplish color prevailing, though yellow and mottled are not uncommon. The porphyries appear to have been poured out over the metamorphic rocks; from the south side of the Black-tailed Deer Valley they project out from the hills in beds much like basalt. The configuration of the surface where the porphyries prevail is quite peculiar—sharp, rounded, conical peaks, with deep ravines or gorges. These peaks are all capped with the porphyries. Immense quantities of the broken fragments or *débris* lie on the summits and sides of these hills. On the east side of the valley the Pliocene beds reach a thickness of 500 to 1,000 feet, and are composed of pudding-stones, yellow marls, gray and white fine-grained sandstones, weathering into singular columnar and other architectural forms. All the rocks contain more or less lime. Both Black-tailed Deer and Stinking Water Creeks have their sources in a high range of limestone mountains, 9,000 to 10,000 feet above the sea level, the highest peaks rising at least 2,000 feet above the valleys of these streams, where they are crossed by the road. High up on the sides of these ridges, reaching

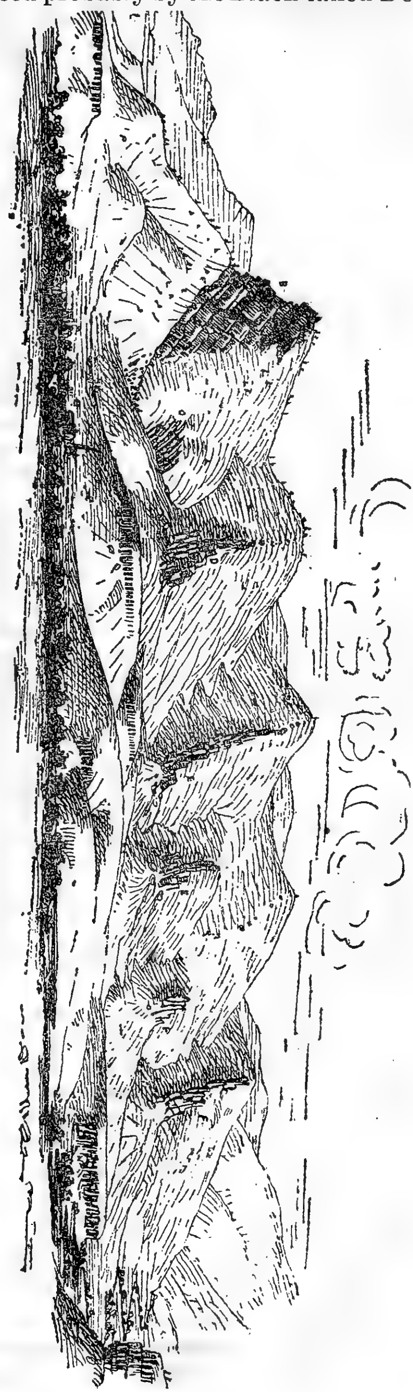


Fig. 6.

METAMORPHIC STRATA, BLACK-TAIL DEER CREEK, BASALT IN THE FOREGROUND.

almost to the summit, are large quantities of drift material, and the Tertiary marls appear to have been elevated nearly as high. All the drift is local, as is usual in these mountain regions, and, by examining it with care, fragments of the different kinds of rocks, brought to the surface in the vicinity, may be found. Of course the later Tertiary beds are made up of the eroded materials of rocks in the vicinity. Much of the sediment was derived from the Carboniferous limestones, and hence their marly character. The apparent inclination of these great limestone ridges or mountains is in every direction, when examined in detail, but the trend of the ranges is about northwest and southeast, and the aggregate inclination northeast, although some of the strata in the highest ridges incline north 60° to 70°; another portion northwest 15°. There is a somewhat peculiar feature about all the ridges since leaving the Rocky Mountain "divide," and that is the evidence, from their external appearance, of comparatively recent elevation. The outcropping edges of the strata appear as if they had been lifted up, without any of the usual proofs of wearing away by atmospheric influences, and the *debris* on the sides and about the base would indicate that the elevation had been prolonged up to the present period. On the summits of these ridges, are great quantities of dead pine-trees, scattered around without a trace of any younger trees or shrubs to take their places. This is not an uncommon feature in many portions of the Rocky Mountains. May it not be possible that these mountain ridges are slowly rising at the present time; that they have reached an elevation that does not admit of the continued existence of these pines, which evidently grew well under favorable conditions which seem now to have entirely passed away? On the north side of Black-tailed Deer Creek, there is another exposure of the gneissic rocks in a series of uplifted ridges, inclining about northeast, at angles varying from 30° to 60°, (Fig. 6.) In the foreground are the modern basalts, with an irregular columnar structure underlaid with modern Pliocene deposits. It is a similar exposure, or, perhaps, a portion of the same exposure on the south side previously described, through which Wild Cat Cañon passes to the valley. These exposures of the gneissic rocks seem to be local, and are doubtless due to the stripping off of the superincumbent formations. They undoubtedly form the basis rocks of the whole country. In the mining regions they are brought to the surface more frequently, and occupy much larger areas. The broad, beautiful valley of the Black-tailed Deer Creek is worn out of this belt of gneissic rocks, and grows broader until it expands out into the still wider valley of the Beaver-head Creek to the northwest, about twenty miles below our road. In these granitoid rocks there is the usual variety of texture, some composed of an aggregate of crystals of feldspar, decomposing readily like sandstone; others with a schistose structure from their micaceous character; others so hard as to resist the influences of the atmosphere—a kind of feldspathic quartzite in large angular blocks. Are not these remnants of old mountain-ranges that have resisted, to some extent, the powerful erosive influences that have been brought to bear upon them for many geological ages?

From the valley of Black-tailed Deer Creek we passed over the "divide" to the sources of the Stinking Water. Our camp in the valley was 5,973 feet, but the elevation of the divide is 6,657 feet. On our way over we found here and there patches of basaltic rocks, fragments of the great crust that once covered all the modern deposits of the valleys. On the "divide," at the head of a cañon that leads into the valley of Stinking Water, are some rather large exposures of the basalt, with a sort of

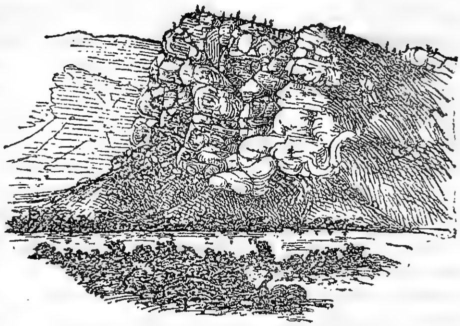
bedding which may be called shelving, or a splitting into layers of greater or less thickness, depending on the compactness of the material. Sometimes the modern basalt caps the quartzites, of which we have several examples on our way to the main valley of the Stinking Water. Still farther down we find a branch of the Stinking Water called Sweet Water, cutting directly through a mass of variegated porphyries, like those in Wild Cat Cañon, forming the Sweet Water Cañon. The great variety of colors which these rocks present, the height and abruptness of the walls, and the style of weathering on the summits, give to the scenery in this region a weird kind of grandeur and beauty. At the base of the walls is a vast quantity of *débris*, composed of the fragments of porphyry. The sides of the porphyritic walls show a regular bedding like strata, in layers from an inch to a foot or more in thickness. At the lower end of the cañon, the gneissic beds appear beneath the porphyries, showing the character of their connection admirably. The former rest upon the upturned edges of the quartzites, as if they had been poured out in a fluid condition, filling up all the irregularities of the surface.

The geological character of this immediate region may be expressed simply as very modern basalt, capping rocks of different ages, which may be in the vicinity of the point of effusion. We then have a group of modern Tertiary beds, probably Pliocene, filling up the valleys and irregularities of the surface everywhere, except on the summits of the highest mountains. During the latter portion of the Tertiary age, the entire northwest seems to have been a fresh-water lake, with vast numbers of mountain elevations occupying a greater or less area, not unlike some of our inland lakes at the present time, on a small scale, with the more elevated points and mountain ranges rising above the surrounding waters. These modern deposits have been elevated also to a certain extent, as there is in many instances an inclination of the strata from 1° to 5°. These cover the porphyries which were effused at a period far back in the past, subsequent to the deposition of the former rocks described, but how much further back into the past I found no evidence to determine. I have as yet been able to find the porphyries only in connection with the gneissic rocks. The forces which operated to lift the gneissic rocks must have acted long prior to those great elevatory movements which affected the sedimentary strata, and although the porphyries seemed to have flowed out over the gneiss since the strata have been elevated to their present position, it is not possible for me to give the precise geological period when these events occurred. Usually either lower Silurian sandstone or Carboniferous limestone rests upon the metamorphic rocks. In a few instances the inclination of the Paleozoic beds above conform with the granite rocks below in such a way that I have been led to believe it possible that the dynamic movements that affected both groups were synchronous. But in most instances there is a greater or less want of conformity between the metamorphic rocks below and the sedimentary beds of any age that may rest upon them. The next group of rocks is composed of stratified gneiss of every possible texture and composition, from the most durable compact feldspathic quartzite to rotten micaceous schist, warped and folded in every way. After passing down the Sweet Water Cañon about five miles, we come out into an open valley, or a sort of expansion. The porphyries, which were previously horizontal in their position, here show a dip of 20°, and about midway in the wall-like front there is an apparent division by a bed of volcanic sandstones about

four feet in thickness. There were three periods of effusion: first, the outpouring of igneous matter over the granitoid rocks; secondly, the deposition in water of about four feet of volcanic sediment; and thirdly, an effusion of igneous matter again like the first. After leaving the cañon, we come out into an expansion of the valley, about ten miles in length and an average of two to four miles in width. This area is surrounded on all sides by ranges of mountains, but covered with a thickness of several hundred feet of modern Tertiary beds. As exposed along the channel of the streams we have at the base 50 to 80 feet of yellowish-white and creamy laminated marls; then 100 feet of cream-colored marly sandstone; and overlying this an indefinite thickness of gray sandstone and pudding-stone. These modern beds jut up against the rotten granites on the south side, inclining toward them about 3°. They seem to be entirely influenced by the ranges on the east and north sides. The weathering is of the same architectural character as the well-known "bad lands." As we leave the Sweet Water and come on to the Stinking Water, the bluffs of Tertiary are quite high, 80 to 100 feet, composed of alternate layers of sandstone and fine marl. The sandstone layers are quite hard, and in the process of weathering project like shelves, giving to the vertical bluffs a singularly rugged appearance. On the east side of the valley the range of mountains is the same as those about the sources of Black-tailed Deer Creek, and are composed of limestones and quartzites of Carboniferous age. The inclination would show that this valley formed a lake basin, with the granites on the west side as a shore-line, and a monoclinal limestone ridge as the shore-line on the east. This valley is well watered, the soil is fertile, and the grazing excellent, and already most of it is occupied by farmers and stock-raisers. The elevation is 5,300 to 5,400 feet, and inclosed, as it is, on all sides by mountains, must be protected from the extremes of cold. On the west side of the Stinking Water, just above the cañon, is one of the largest springs thus far noticed on the route. It must have been in operation for ages, for there are beds of limestone 80 to 100 feet in thickness precipitated from the water. The water at this time issues out of a basin about 150 feet above the Stinking Water, and covers the sides of the hills with the sediment. The rock varies in texture from a compact white limestone to a soft spongy mass. A snow-white efflorescence—soda, perhaps—covers the surface in some places. The older deposits of this spring form the most beautiful white limestone, which would be most excellent for building purposes or for burning into lime. The beds dip west 10° to 20°. This is a most remarkable deposit, though a local one. The basis or underlying rocks are quartzites and granites, inclining east 40° to 50°. Overlying them, further down the stream, in the cañon, are limestones with well-marked Carboniferous fossils. About five miles below the junction of the Sweet Water branch with the Stinking Water, the latter stream passes through a gorge or cañon, and, as we descend the stream between the narrow, rugged walls, we have on the left or west side a group of quartzites of various textures, which had not been observed previously. They are composed of an aggregate of crystals of quartz, brown and rusty drab-brown color, inclining east at a high angle. On the right or east side are the overhanging projecting edges of beds of massive quartzite, rising 800 to 1,000 feet above the bed of the creek. The streams here pass through a gorge between the ridges inclining in the same direction, which I have called a monoclinal interval. We here find exposed one of the remarkable series of quartzitic strata mentioned above, rising to the summits of the east side of the cañon, huge cubic blocks of which have fallen down and are strewed through the gorge. Underneath is an immense

thickness of black micaceous gneiss, with seams of white quartz, the coarse feldspathic granites, literally an aggregate of large crystals of quartz and feldspar, then underneath the black gneiss again. In this cañon there is a most interesting illustration of the weathering of the reddish feldspathic granites by the peeling off in thin concentric layers, or as I have denominated it in my former reports, disintegration by exfoliation. I have never observed a more marked example anywhere in the West, and Fig. 7 shows it well. After passing through the cañon a distance of about three miles, the road bends to the north, leaves the valley of Stinking Water, passes over a high divide to Alder Gulch, in which Virginia City is located. On the right or east side of the road, the rather rounded and, in some instances, grass-covered hills, continue all the way. On the left or west side, the gneiss and quartzite continue for a short distance, when the mountain range, which has hitherto walled us in on the west side of the road, bends a little to the northwest, and extends to the Jefferson Valley, parallel with the Stinking Water, and rises quite abruptly, 2,000 feet above the channel of the stream. The base of this ridge or range is a smooth lawn-like slope, down to the margin of the stream, while the ridge itself is composed of massive beds of limestone inclining 60° to 70°, the outcropping edges projecting sharply on the summits, and the northeast sides sloping down into the plain, like a very steep roof. The valley itself is a beautiful and fertile one, and is one of the numerous valleys that open into the Jefferson Fork. It will average from four to six miles in width and about twenty miles in length below the cañon, and is covered with a moderate thickness of the Pliocene deposits. On the east side of Stinking Water, the rocks are entirely composed of gneiss, of the usual variety of texture and composition, the strata inclining southwest at various angles, so that the Stinking Water really flows through a synclinal valley from the cañon to its junction with Jefferson Fork. In the valley and among the foot-hills of the mountains, are here and there patches or remnants of the great basaltic crust that must at one time have extended over most of the area occupied by the valleys. From the Stinking Water to Virginia City, a distance of about ten miles, the rocks observed were of metamorphic origin, with here and there indications of the effusion of basalt.

Fig. 7.



WEATHERED GRANITES AT MADISON CANON.

Virginia City is located in the center of one of the richest mining districts of Montana, and a description of the surrounding country would apply, in most particulars, to all the mining portions of the Territory. The precious metals, as gold and silver, are found, so far as my observations have extended, entirely in the metamorphic rocks which hold a position below all groups of strata that we have been in the habit of regarding as Paleozoic. Whether they belong to the series denominated in Canada the Huronian or Laurentian, we have no data to decide positively; but inasmuch as they are all clearly stratified rocks, they are plainly of sedimentary origin. These rocks underlie the entire country west of the Mississippi. We may safely assume this position whether they are vis-

ible at the surface or not. As a rule, they are separated into thin layers, with a great variety of texture, from the most unyielding quartzite to rotten gneiss. There are also distinct intercalated layers of clay or sand. As a rule, these rocks become more massive as we descend; the softer beds of clay and sand cease, until we find nothing but massive beds, hundreds of feet in thickness, of homogeneous granite. All these rocks have suffered erosion to a greater or less degree—sometimes they are entirely swept away, down to the massive granites. It is in the series of metamorphic strata, estimated to be several thousand feet in thickness, that the principal deposits of gold and silver, in the Territories of Montana and Colorado, are found. The altitude of these rocks depends, of course, on the forces that have operated in the past to elevate the ranges of mountains. At any rate, there is no uniformity any more than there is in the surface of the country at the present time. We know one thing, however, that as a rule the oldest of these granite rocks crown the loftiest of the mountain ranges. The relations which the well-marked, stratified granites sustain to the older and more massive granites is nowhere better shown than in the mining regions of Colorado, especially at Central City and Georgetown.

In general terms, we speak of the geological structure of Montana as extremely simple; and so it appears to be; but when wrought out with the care that will be absolutely necessary to a truthful delineation of the details, it will be found to be exceedingly complicated. We may be examining one of the mining districts, for example, and we may conclude that only metamorphic strata will be found over the entire area occupied by the mines; but perhaps, on a careful study of the details, we shall find everywhere scattered about patches of all the Paleozoic rocks known in the West, and quite possibly portions of the Mezozoic and Cenozoic also. In the valleys and gulches, upon the summits of the highest mountains, and in the most unexpected places, fragments of the Carboniferous limestones will be found. We may take the position therefore that the entire surface of the country has been at one time covered with a greater or less thickness of sedimentary rocks. It is possible, though not at all probable, that there are restricted areas in this portion of the West where no unchanged sedimentary deposits have ever existed, and it is possible that over considerable areas no strata newer than Carboniferous may have been laid down. There is reason to believe, however, that the entire series of strata known in the northwest, above the metamorphic rocks, were originally deposited all over the Territory of Montana. We may conclude, therefore, that the erosive forces have operated with great power in the district around Virginia City, stripping bare to the metamorphic beds, large areas. In the mining districts, in connection with these agencies, was the wearing out of so many gorges, or gulches, as they are usually termed by the miners. We may take as an illustration some rather prominent streams in the vicinity of Virginia City; and if a careful detailed survey were made, we should find that there is a main valley or gulch, with great numbers of side-gulches running up into the heart of the mountains on either side. The main stream may be fifty to one hundred miles in length, and on either side are these branch gulches, usually from three to ten miles long. These gulches may be carved entirely out of the massive strata, or they may be partly due to erosion, and partly to an interval, formed during elevation, that is, a monoclinal valley. The influence of the erosive forces, which acted with great power, and probably through long periods of time, though widely distributed, are local in their results. In other words, while the erosive forces were in operation all over the West, there was no widespread connection,

so that the eroded materials of one locality were swept far away to widely separated localities. Therefore, the superficial deposits of the mining districts, which are usually very extensive, have their origin in the immediate districts where they are now found. We may take as an illustration the Alder Gulch, which is about twelve miles in length, and varies from an eighth to half a mile in width, and is literally filled up with sand, gravel, and bowlders, all of which were derived from the mountains in the immediate vicinity—indeed, within the limits of the drainage of that gulch. We may thus determine with a good degree of certainty that, when we find placer-diggings, the source of the gold thus found is not far distant, and is most probably within the limits of the drainage of that locality. The origin of the placer-gold is undoubtedly due to the erosion of the rocks in which it was originally precipitated; and inasmuch as the gold, so far as we now know, is found altogether in the gneissic strata, its existence in the various gulches, among the sand and gravel, is due to the grinding up by water of the surface of the metamorphic rocks in the vicinity. Instances have occurred where very rich placer-diggings have been found in gulches, but the rocks which appear to have given origin to the float-gold, yielded no rich lodes. This may be accounted for on the ground that the upper portions of the lodes contained all the rich ore, and that in the process of erosion this ore was all ground up, while the remainder that is left may have been lean, or even contained no gold at all. The principal lodes that have been worked in the vicinity of Virginia City are near the head of Alder Gulch, and are as yet only moderately successful. Up to this date Montana seems to have gained its high state of prosperity principally from the richness of its gulch deposits. It is estimated that $30,000,000 of gold have been taken out of Alder Gulch since its discovery in 1863. The lodes all have a general strike northeast and southwest. Perhaps they would be termed north and south lodes. I was informed that all the lodes in the Territory have that general trend. The gangue material is very similar to that in the gold lodes about Central City, Colorado—quartz and feldspar of various textures. Sometimes the gangue is very hard and compact; again it is rotten quartz, as it is termed by the miners. The country rock is mostly gneiss, also exhibiting various degrees of hardness as to texture. The dip of the lode matter is nearly west 50° to 60°. The trend of the metamorphic strata is about northwest and southeast. The Alder Gulch closes up in a ridge of limestone, which forms a most remarkable wall, effectually shutting off all communication with the Madison Valley to the east of it. The altitude of Virginia City is 5,713 feet, while the head of the gulch is about 500 feet higher, and around it a wall of limestone rises up with its outcropping edges toward the gulch 800 to 1,000 feet, so that this ridge is at least from 7,000 to 7,500 feet above the sea. From its summit we can see at a glance, a broad extent of country. The Madison Valley, with all its beauty of outline, is visible for thirty or forty miles, while to the west and northwest the eye passes down the different gulches and branches of the Jefferson Fork into that broad valley, over the side ranges which intervene. We know that these limestones are of Carboniferous age, and are a portion of the series that has extended persistently all along our route from Salt Lake Valley, and perhaps even the same great ocean bottom that extended, during that age, over the area from the Mississippi Valley to the Pacific Ocean, and we know not how much farther. As a general rule, these limestones always contain a few fossils, enough to guide us in our wandering examinations, but the rocks are usually so compact, and sometimes so much changed,

that few can be obtained in a condition such as to be identified with certainty. The species are not numerous, as will be seen by the list in a subsequent portion of this report. At the head of Alder Gulch, a *Syringopora*, *Rhynconella*, and *Productus* were found, and quite a number of other species, which will require further study. The limestones pass down into very hard cherty quartzites, and then rest unconformably on the metamorphic rocks. The strike of these limestones is about north and south, bearing perhaps a little west of north and east of south. As we have previously stated, the principal basis rocks in the vicinity of this gulch are gneissic, of varied composition and texture, with a high ridge of limestone at the head of the gulch, forming a sort of wall, with the outcroppings or basset edges of the strata pointing west of north, and formerly extending in a horizontal position all over the surface. Returning to Virginia City, on the high divide, on the east side of Alder Gulch, about half-way between the head of the gulch and Virginia City, there are patches of limestone, underlaid with cherty quartzites. These isolated masses are at different elevations, sometimes upon the summits of the highest ridges or down in the side gulches, showing that a greater or less thickness of the underlying granitoid rocks have been worn away. They also remain as remnants of the great horizontal mass, 2,000 to 4,000 feet in thickness, that once extended across the entire area.

The greater portion of the surface of the high divides, however, are covered with basaltic rocks. They cap the hills, forming sort of plateaus or benches, and along the sides of the gulch, show steep sides one hundred feet or more in height, with the appearance of stratified layers in a horizontal position. As I have frequently stated, the effusion of the basalt is a modern event, probably occurring, for the most part, near the commencement of our present period, after the entire surface reached nearly, or quite, the present elevation. Hence we find points of effusion in numerous localities. The igneous lavas flowed out in layers, and inasmuch as a considerable amount of erosion of the surface has taken place since, the sides of some of these basaltic accumulations have been worn down so as to show with clearness the edges of the different sheets of basalt as it cooled. From a high elevation, one may see in every direction numbers of these points of effusion. The streams which wear out the gulches pass through the basalt, deep into the granitoid rocks. Scattered over the surface also are patches of the Pliocene marls and sandstones underneath the basalts, as heretofore. In the mining districts around Virginia City, we have a thick series of stratified granitoid rocks at the base, in which the precious metals were originally located; upon them rest the quartzites and limestones of Carboniferous age, and filling up some of the inequalities of the surface are the modern Tertiary beds; and covering all, over restricted and isolated areas, are beds of basalt. The force of erosion which operated on all these rocks to accumulate the vast quantities of sand, gravel, and bowlders in the gulches must have been very great. Mingled with the superficial deposits are fragments of all the varieties of rock formations in the vicinity. Although more or less rounded by attrition, in the great thickness of local-drift may be found all the varieties of the granitoid and other rocks that are sufficiently compact to resist the atmospheric agencies—quartzites, limestones, with fossils, masses of basalt, &c., &c., &c. Most of these rocks can be traced to their parent beds in the vicinity; a few may seem to have strayed from other districts, but the strata to which they originally belonged may have occupied a restricted area, or had a local existence, and thus, in the erosion of the surface, been entirely worn away, or may be concealed by Tertiary or superficial deposits. In the Alder Gulch

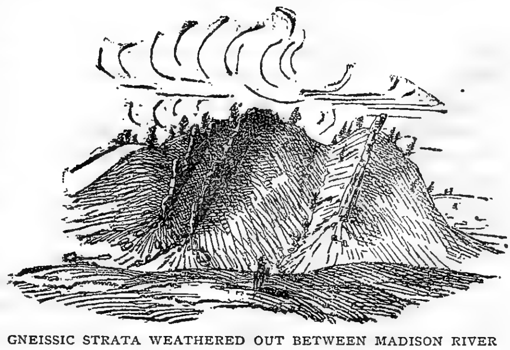
the miners found in the bed rock numerous "pot holes," with large rounded masses, six to twelve inches in diameter, in the cavities. Some of these spherical masses were basalt and others composed of a sort of basaltic sandstone.

Remains of a species of elephant, probably *Elephas primigenius*, were found in the auriferous gravel, twenty-five feet below the surface. A large tusk, with a number of teeth, ribs, and fragments of bones, was found. I am indebted to Judge Lovell for the gift of a fine collection of these remains, which are now safely secured in the museum of the Smithsonian Institution. The tusk is especially remarkable, and was preserved with great difficulty. These fossils have been found in other portions of Montana, in the gravel, especially in the Last Chance Gulch, near Helena, where a large quantity of these valuable fossils were discovered.

One tooth is said to have had a portion of the jaw-bone attached, and to have weighed twelve pounds. The bones, as well as the teeth, seem to have been partially worn as if they had been drifted about by the waters to some extent, and I think they were washed from the latest of the modern Pliocene deposits, which are abundant all over Montana.

From Virginia City we traveled up a deep ravine to the divide that overlooks Madison Valley. The highest point over which the road passes was found to be 6,857 feet. None of the mountains on this divide were more than 800 to 1,200 feet above this altitude. On the east side of Madison Valley, there is a fine lofty range of mountains, the summits composed of limestones, inclining west, while at the base, and extending high up the sides, are grassy slopes, which give to the valley an attractive appearance to the eye. Along the Madison River, in this portion, are the first series of terraces yet observed. On the west side are three of these terraces or steps; four, if the broad bottom is counted. The first terrace is 25 feet above the river, with an average width of half a mile; second terrace, average width one mile, 100 feet above the first; third terrace 50 feet above the second; and the fourth 200 feet above the bed of the river. These terraces are much more like table-lands on the east side than on the west. On the west side of the Madison, on the divide, the limestones extend over from the head of Alder Gulch across the Madison to the eastward. The mountains between the Stinking Water and the Madison Valley are not high, but extend about northward to the Jefferson in the form of a ridge, composed almost entirely of granitoid rocks, with outbursts of basalt, and here and there patches of Pliocene deposits. The dividing ridge between the Jefferson and the Madison Rivers varies from twenty to thirty miles in width. Outcroppings of massive gneiss project up here and there over the entire extent, giving to the surface a rugged but picturesque appearance, (Fig. 8.) The limestones and quartzites are nearly or quite all stripped off, and the more yielding portions of the granite rocks have worn down, and the surface smoothed and grassed over, so

Fig. 8.



GNEISSIC STRATA WEATHERED OUT BETWEEN MADISON RIVER AND GALLATIN, ON ELK CREEK.

that there is much excellent grass land among the granite ridges. The patches of Pliocene marl here and there aid in smoothing the rougher portions of the surface. That portion of Madison Valley immediately west of Virginia City is about seventy-five miles from north to south, and ten miles from east to west, closing up at the south end and forming a fine cañon through gneissic granites at the north end. These granites are mostly feldspathic, the feldspar predominating, and in most instances composed only of feldspar and quartz, with iron diffused through the mass. This valley, at one time in the past, formed the bed of one of the great chain of fresh water lakes, as is shown by the lake deposits which underlie the upper terraces, and jut up against the mountains on either side. This deposit is also covered in some places with a bed basalt.

CHAPTER III.

FORT ELLIS—MYSTIC LAKE—SOURCE OF THE GALLATIN—TRAIL CREEK—CROW AGENCY AND FIRST CAÑON—EXIT OF THE YELLOWSTONE.

Fort Ellis is located on the east bank of Mill Creek, one of the sources of the East Fork of the Gallatin, and from its position, overlooks one of the most beautiful valleys in Montana. It is surrounded on the east and north sides by ranges of the hills and mountains which form the divide between the waters of the Yellowstone and Missouri Rivers. After our long journey across the dry plains from Salt Lake Valley, we found this point a most agreeable resting-place. Every courtesy we could desire was extended to us by the officers. Captain J. C. Ball, at that time in command, during the temporary absence of Colonel Baker, afforded us every facility to aid us in our preparations for our explorations up the Yellowstone, and his suggestions, from long experience in western campaigns, were of the highest value to us throughout the trip. Indeed, the favors that we received at this post, both going to and returning from our Yellowstone exploration, were indispensable to our complete success. Fort Ellis, although considered one of the extreme frontier posts, and supposed to be located among hostile tribes of Indians, really commands the valleys of the Yellowstone and the three forks of the Missouri, the finest and most productive portion of Montana. It is a very pleasant station, surrounded with beautiful scenery, with a climate that can hardly be surpassed in any country. Streams of pure water flow down the mountain sides, cutting their channels through the plains everywhere. The vegetation is most abundant. Bozeman is a pretty town, with about five hundred inhabitants, situated three miles below, surrounded on every side with well-cultivated and productive farms. It is most probable that within a short period the Northern Pacific Railroad will pass down this valley, and then its beauty and resources will become apparent.

The drainage of the Gallatin is composed of a large number of little streams that rise in the great divide for a distance of eighty to one hundred miles, and each of these little streams gashes out a deep gorge or cañon in the mountain sides. The geology is thus rendered comparatively simple in general terms, and yet in its details it is remarkably complicated. Two forces seemed to have operated here to give the present configuration to the surface, and whether they may have acted synchronously or at different periods, or both, is not

very clear. I am inclined to think that the earlier force operated to elevate the long continuous ranges of mountains, the nucleus of which is the granitoid rocks, with the unchanged sedimentary beds upon the sides and summits inclining at various angles. There was originally a general trend to these mountain ranges that might have been called specific, perhaps, and in the aggregate it is quite clear at the present time, and is a little west of north. But when we come to study the minor ridges, the unchanged rocks seem to incline in every direction and at all angles from 1° to 90°, and even sometimes past a vertical. Another force, which has greatly influenced the form of the surface, and one which, whether it operated synchronously or not, certainly acted with full power at a subsequent period, concealing the metamorphic rocks and the older sedimentary strata over large areas, and building up most of the loftiest peaks. In the previous pages of this report, I have constantly alluded to the exhibitions of the outflow of igneous matter at almost every point of our journey; but about the head-waters of the Missouri and Yellowstone, I have estimated that at least three-fourths of the area is covered with igneous rocks. Taking the valley of the Yellowstone from its sources in the great water-shed to the mouth of Shield's River, an area one hundred and fifty miles from north to south, and fifty from east to west, we find the evidences of volcanic action upon a tremendous scale, and igneous rocks cover almost the entire area. Wherever the metamorphic and sedimentary rocks are exposed in the vicinity of these extensive outflows of igneous material, their history becomes much complicated and the difficulties encountered by the geologist are greatly increased. The valley of the Gallatin, like the valleys of all the streams in Montana, is undoubtedly one of erosion originally, and was also the bed of a lake. This lake basin extended down to the junction of the Three Forks northward, and the modern deposits are found all along the base of the mountains on either side of the valley up to the very sources of the river, sometimes rising quite high on their sides. So great has been the removal of sediment during and since the recession of the waters of the lake, that it is not always easy to determine the entire thickness of the original deposit. Remnants are left, however, at different points, sometimes in the higher ranges of foot-hills, or in patches among the metamorphic rocks at considerable elevation on the divides between the Gallatin, Madison, and Jefferson Forks. Areas of greater or less extent occur 600 to 800 feet above the channels of the rivers, showing that the waters must have been so high that only the more elevated summits were above the surface. Opposite Fort Ellis are some high hills 600 to 800 feet above the valley below, composed of the well-known Pliocene marls, sands, sandstones, and pudding-stones, horizontal for the most part, or inclining at small angles. Among these beds are outflows of basalt in a number of localities, but the disturbance of this group has been slight. In most cases these deposits jut up against the sides of the mountains, and when occurring in contact with the older rocks do not conform. The group of hills opposite Fort Ellis extend down nearly to Flathead Pass, and, having escaped erosion and removal for the most part, are left as some proof of the original thickness of the lake deposit. Upon the tops of the hills there is a considerable thickness of local drift, and scattered thickly over the surface are rounded bowlders in great numbers and variety.

To study the older rocks to advantage, we must extend our examinations to the numerous gorges, or cañons, in the mountains, which, cutting through the upheaved ridges at right angles, reveal more or less clearly the order of the superposition of the strata. In Flathead Pass, Bridger

and Bozeman Passes, the limestones are remarkably well shown, in some instances inclining 80° with the upper edges of the strata a line of rugged columns. The more yielding beds have been removed from the limestones, leaving them on either side of the cañon like walls, while atmospheric agencies have worn out the upturned edges into the most picturesque, jagged forms. The cañon about two miles above Fort Ellis, carved out by Mill Creek, forms an interesting subject of study. The entire range is a true anticlinal, trending northwest and southeast, with the more abrupt side northeast. This side has also been subjected to much erosion, so that the more modern beds are seldom visible, the greater portion now remaining, belonging to the metamorphic series, or to the Carboniferous age. But on the east side, covering the hills, and cropping out deep down in the valleys, is a vast thickness of steel-gray or somber-brown sandstones. The composition and texture of these rocks are quite varied. There are alternately hard and soft layers, that is, clay and sandstones. The clays are quite uniform in their character, and are so thick in the aggregate as to give a rounded, smooth outline to the hills, and by weathering, to conceal the rocky strata beneath. East of Bridger's Peak, and on the divide, high up in Bozeman and Bridger Passes, are a large number of exposures, sufficient to show that there are here about 1,200 to 1,500 feet of strata belonging to the Coal Series. Whether this group belongs to the Upper Cretaceous or Lower Tertiary, or both, I will not delay at this time to discuss. No animal fossils were found, but a fine collection of well-preserved vegetable remains were obtained, and are now in process of description by Mr. Lesquereux. The composition of these rocks is mostly sand of various degrees of fineness, some argillaceous and calcareous sandstones. Most of the sandstones contain a small per cent. of lime. Near the head of Spring Cañon, about three miles east of Fort Ellis, a coal-bed crops out near the bed of the creek, from which several tons of excellent coal have been taken. The opening has been made to the depth of 180 feet. There are beds of clay on either side of the coal-seam, as usual. The strata are nearly vertical, dipping north 80°. Great quantities of impressions of deciduous leaves are found in the rocks along the borders of the streams, and on the hills. These fossils seem to be confined to no particular beds, but to occur in different layers of rocks, adapted to preserve them, above and below the coal and extending through the series of strata. A large number of specimens of plants are described by Mr. Lesquereux in a valuable report in another portion of this volume.

We will now return to the west side of the range, and pass up the cañon to the eastward. The stream which has cut its way through this high ridge is a fine specimen of a mountain torrent; the water is pure and full of trout. As we approach the base of the hills from the level terrace on which Fort Ellis is located, the gorge appears so narrow as to be impassable; but on entering it, we find ample room for a bridle-path, and we make our ascent without difficulty. As this is the cañon which is regarded as most available for the passage of the Northern Pacific Railroad, it is invested with no small degree of interest. If the road ascends the valley of the Yellowstone River, it will cross the divide just above the mouth of Shield's River, and ascend the valley of a little stream to the westward, which rises within a few yards of the source of the one that flows through the cañon; so that the greater portion of the rock excavations has already been performed by nature, with these two beautiful streams as her agents. This lets the road into the Gallatin Valley, where it can go up to the junction of the Three Forks; thence, up the Jefferson Fork, through the finest portion of Montana,

with scarcely an impediment. But this subject will be treated more in detail in subsequent portions of this report. We may, before describing the details of the geology of this district, enumerate the formations we may expect to meet with. We have mentioned the existence of a large thickness of the lake deposits, and, frequently covering them, beds of basalt; but still the latter, although a modern outflow, is not confined to the vicinity of these Pliocene marls, but may burst up through any of the rocks and overflow their surfaces. We are liable to meet with them anywhere, and in most cases they predominate over all others. The next group of strata older, are the coal-beds, which are exposed in a break in the range, and aid in concealing the older rocks for an interval of four or five miles, between the Cañon and the Gallatin Mountains. Then come a few obscure exposures, which are, no doubt, of Cretaceous age, though no fossils were observed; below them are well-defined Jurassic strata, and below these the quartzites and limestones of Carboniferous age. None older than the latter are exposed in this gorge. A few miles farther to the southward, as well as to the northward, older rocks are brought to the surface, and we find that the core of the mountains is composed of granitoid rocks.

Now, if we examine this range of mountains a little more in detail, we shall find, as we enter the cañon, a series of beds which are probably Cretaceous, but dipping at various angles. In some portions of the range, fragments of the beds are lifted up to the very summit, so far as to form a broken arch. This arch is well shown on the north side of the cañon, while on the south side the two sides of the anticlinal terminate in high jagged points of limestone, 1,000 to 1,200 feet above the plain below. In the supposed Cretaceous beds no well-defined fossils could be found, but in some beds of arenaceous limestone, were bivalves, which I have no doubt are of that age. Below this group there is a series of alternate layers of arenaceous clay, gray limestones, and sandstones, with layers 2 to 4 feet thick, composed of an aggregate of broken shells, with now and then a fragment perfect enough to be identified so as to show their Jurassic age. Below these are some red sandstones and clays, which might be remnants of the Triassic, and, as they contain no fossils, any opinion about them is conjectural. I think, however, that they are all Jurassic or Carboniferous. We then come to a great thickness of Carboniferous rocks, first quartzites, gradually passing into limestones. Rocks of Carboniferous age form the great mass of the minor ranges of mountains.

On the morning of July 12, a small party of officers from the fort, under the guidance of Captain S. H. Norton, made a tour of exploration to a little lake, embosomed among the mountains, about twelve miles distant. We were accompanied also by Dr. Campbell and Lieutenant Jerome, to all of whom we were indebted for many kindnesses and much information. Our course was nearly south from the fort. After passing over the beautiful grassy plain between the middle and east borders of the Gallatin, we ascended the high hills on the west side of the dividing range between the waters of the Yellowstone and the Gallatin. These hills are so covered with *debris* and a heavy growth of vegetation that not even in the ravines can the real basis rocks be seen. On either side of us, however, in the very highest ridge, the limestones are visible, with the reddish sandstones and clays, so that we may infer that the Jurassic or Cretaceous are concealed beneath this superficial drift. After winding among these hills, through a garden of most beautiful wild-flowers, we reached the little lake, which, on account of its great beauty, and being partially hidden, we called Mystic Lake.

It is really an expansion of one of the branches of the Gallatin, about one-fourth of a mile wide and three-fourths of a mile long. The scenery all around it is very attractive, and Mr. Jackson succeeded in securing some most excellent photographs. The hills, immediately surrounding the lake, and, indeed, all the lower hills, are made up of sedimentary rocks, and just on the shore of the lake is a considerable thickness of grayish-brown arenaceous limestone filled with fossils, as *Camptonectes bellestriata*, *Pinna*, *Modiola*, *Myacites*, *Pholodomya*, and others. A patient search at this locality would have been rewarded with many more species, but enough were secured to fix the age of the beds as Jurassic beyond a doubt. A group of strata once fixed in the scale by such an array of evidence, forms a horizon which may be extended, with certainty, in every direction for a great distance, even though the usual fossils may not be found. The stream that comes into the lake passes through a deep gorge, walled on either side with Carboniferous limestones. But to the west and north, the mountains rise in rounded dome or cone-like peaks, 1,200 to 1,500 feet, and in a few instances 2,000 feet above the valleys below. These high mountains are composed of volcanic materials, a core, as it were, of more or less compact basalt, with volcanic breccia all around it. Huge masses of this volcanic breccia have fallen down into the valley and around the lake. High up on the sides of the mountains, in some places, the igneous rocks present the appearance of strata, which have suddenly been poured out in beds, and cooled in separate layers, and these layers incline at moderate angles, as if they had been acted upon by subsequent action of the volcanic forces. All the lower hills, which are comparatively sloping and underlaid with sedimentary rocks, rising to the height of 200 to 500 feet, are covered thickly with vegetation, mostly pines, but the higher volcanic ridges are dark, gloomy, and bare, presenting the aspect of rugged desolation. But in the little valleys and along the margins of the streams the vegetation is quite luxuriant, and the flowers are varied and abundant, rendering traveling among these wild and apparently inaccessible hills charming beyond description. The soil is, of course, made up of portions worn away from all the different kinds of rocks in the vicinity, both the igneous and sedimentary. Thus a remarkably rich soil is produced, which, during the short season of midsummer, clothes these valleys with a vegetation of bright-green, and flowers of all hues. This little lake, as well as the stream that flows into it, is full of trout. The water is very clear and pure, always cool, fed as it is by the melting of the snows from the surrounding mountains.

Without entering into further details of the geology of this range, I might say that there is no regular inclination to the sedimentary rocks of those ranges that have been so much influenced by igneous action. We find at one point the Carboniferous limestones on the east side of a deep ravine, extending down the sides of the mountain like the steep roof of a house, while on the opposite side the same rocks have been lifted up a thousand feet or more, the upturned edges indicating by their appearance that the period of the uplift was a modern event. It is my belief that the principal portion of this volcanic action occurred just prior to the present period, when the sedimentary and granitoid rocks had been elevated somewhat as we find them at present, and that the chaos which we everywhere see was produced by this general effusion of igneous material, thus tossing the strata in every direction.

A considerable amount of erosion may have occurred since, but most of it had already been performed. The Carboniferous rocks, up to the Tertiary Coal Series, inclusive, were in the same fragmentary condition in which we find them now.

On the 15th of July we bade farewell to the hospitable officers of Fort Ellis, and with an excellent outfit, for which we were greatly indebted to their kindness, started, with confidence and hope, toward the wonderland of the Yellowstone Valley. We followed a well-traveled road, which wound around among the hills, diverging by numerous branches in almost every direction. After passing behind the main range to the north, we turned our course to the east, up the valley of a little branch of Mill Creek, and soon passed over the divide into the waters of the Yellowstone. The water-shed and the geological divide are by no means identical. The little stream cuts directly through the heart of the anticlinal, and rises high up in the coal group east of the limestones. East of the narrow belt of limestones the coal strata occupy the greater portion of the interval to the Yellowstone River. These beds incline at various angles east and northeast. A large quantity of finely preserved impressions of leaves of deciduous trees were found. The texture of the rocks was quite varied, and the examples of oblique lamina of deposition were quite conspicuous. The sandstones were usually quite fine and close-grained, but sometimes they passed into a fine puddingstone. Interstratified with these rocks are layers of compact basalt, and not unfrequently on the summits of the hills are thick masses of it. It will be seen at once that the dark brown or somber hue of this great group of strata (1,200 to 1,500 feet) is not the original color, but caused by the subjection of the strata to a greater or less heat during the period of volcanic activity. Wherever the igneous matter has come in direct contact with the sedimentary rocks they have been more or less changed. Some of the sandstones have become compact quartzites, but the same dark, gloomy appearance pervades them all.

From the divide between the Gallatin and Yellowstone Rivers, the view is wonderfully fine in every direction. On the north side the hills rise up 600 to 800 feet. The elevation of the divide over which the road passes is 5,681 feet. The principal range of mountains on the south side is mostly of volcanic origin, and rises 800 to 1,200 feet. The belt of Carboniferous limestone seems to have a trend northeast and southwest, preserving its anticlinal character to the Yellowstone Valley, then, crossing the Yellowstone River, is seen only on the sides of the Snowy Range, inclining northwest. Although the general character of the geological structure of the country lying between the sources of the Gallatin and the Yellowstone River appears so simple, yet months of earnest labor would be required to work it out in all its details. The distance is not more than thirty miles. The sedimentary beds are thrown into almost inextricable confusion. I shall endeavor to unravel it in part as I proceed step by step on our journey up the Yellowstone.

It is probable that in general terms the rocks of the country belong only to about half a dozen groups, and yet these are so multiplied into a diversity of forms, and then by subsequent elevation, so mingled together, that at the first glance there seems only confusion; and yet, with the exception of the more modern volcanic forces, there has been a method in their action. So far as the rocks of Carboniferous and Jurassic age are concerned, we may rely with some confidence on their uniformity of character wherever they may occur, but all the others are modified more or less even in their mineral texture at different localities. For example, on our route from Fort Ellis to the Yellowstone River, a distance of about thirty miles, we find the summits of the highest hills covered with a greater or less thickness of a local drift, and wherever the rocks are shown they appear to belong mostly to the Coal Series,

(Eocene.) Interstratified with the beds of this group, are layers of basalt of irregular thickness, some of which is so compact and homogeneous in structure that it must have cooled under much pressure, and perhaps never reached the surface until exposed by erosion or the elevation of the mountain ranges. Then in the valleys of the streams, some with flowing water, others dry, yet all deep and apparently at one time the channels of large bodies of water, are great quantities of the local drift and *débris*, concealing the underlying basis rocks so as to perplex the geologist, and yet an active search will show that along the banks of the stream, a few feet in thickness of some one of the formations of the district will be exposed. It may be the oldest; it may be the latest; we may find an outcrop of massive granites, of stratified granitoid rocks, Carboniferous limestones, or the latest Pliocene marl group; the youngest rocks may cover the loftiest ridges, and *vice versa*. The Pliocene marls do not unfrequently occur in contact with the massive unstratified granites on the summit of the mountains, so that we may step within a few paces from the youngest rocks known in the West to the very oldest. The beautiful, regular curves and flexures in the strata, which continue so systematically over long-extended areas in Pennsylvania and along the Atlantic border, are wanting in the Rocky Mountains. Local curves of remarkable beauty occur in the strata, from time to time, as we shall attempt to show by figures in the final report. Altitude, therefore, gives no clew to the age of rocks. I have also given the angle of inclination of the strata from time to time in my reports. In regard to the more eastern ranges of the Rocky Mountains, the dip and trend are terms possessing some force and meaning, but in the volcanic regions of the Yellowstone and Missouri Rivers such observations seem to be of little value. There is no doubt that, when the whole country has been carefully mapped and the geology worked out in detail, a system will be found in the results of the action of the internal forces that gave to the surface its present form. So in regard to the position of the strata, altitude gives no clew; the oldest, to the Cretaceous inclusive, in the lowest valley, on the summit of the highest range, may be horizontal or incline at any angle. The Carboniferous limestones on the divide between Trail Creek and a little branch flowing into the Yellowstone to the north are vertical, or nearly so, or have been lifted up in broad areas to the summit of the divide, so as to be nearly or quite horizontal, while all around it bend down the same limestones, like the leaves of a table, at angles of 60° to 80°, and in a few instances inclining past a vertical. In the valley of the Yellowstone, these same limestones will be found horizontal, while upon the summits of the mountains, 3,000 feet above the valley, within a few miles, they incline at a very moderate angle. These facts seem to show the importance of having the topography of the country worked out with great care in connection with the geology, in order that the multiplicity of detail may be clearly expressed.

From the summit of the divide down to the ravine of Trail Creek, we can look to the eastward, into the beautiful valley of the Yellowstone River. On the south side is the high range of mountains, at first composed of sedimentary rocks, with their jagged summits rising up 1,200 feet above the valley, and after passing the divide, this range flexes around to the south, extends up on the west side of the Yellowstone, forming the water-shed between the sources of the Gallatin and Madison Forks. After passing the head of Trail Creek, this range is composed almost entirely of igneous rocks, so far as they are revealed to the eye. There is reason to believe, however, that underneath this vast mass of basalt

and volcanic breccia, there are sedimentary rocks, and even the granitoid group, for the latter was well shown in the second cañon. I have already described the existence of great thicknesses of Carboniferous and Jurassic strata on the west side of this range around Mystic Lake. Upon the east side, in some of the gorges or ravines of the Yellowstone drain age, it is quite possible that some of the older rocks are exposed. The highest peaks, many of which are covered with snow all summer, are composed of volcanic breccia; on the north side of Trail Creek there is a range of hills, as they may perhaps be called more properly. These hills are really a group of broken ridges; the anticlinal belt seems to diverge, one portion passing up along the divide or water-shed, between the sources of the Gallatin and Yellowstone, appearing in full force at Cinnabar Mountain; the other following along the north side of Trail Creek, crossing the Yellowstone River at the lower cañons, and extending off on the northeast slope of the Snow Mountains, about the sources of Big Bowlder, Rosebud, and Clark's Fork of the Yellowstone. The amount of erosion in the interval, between these two portions of the anticlinal, has been very great. Not that the valleys have been entirely carved out of the mountains, for they were doubtless, in part at least, and perhaps in all cases, marked out in the process of upheaval. The valley of Trail Creek, which is a narrow gorge at the head, gradually expands out, near its entrance, to the immediate valley of the Yellowstone, a distance of about twelve miles, so that it is about two or three miles wide. We can now see, by fragments of ridges that are remaining, that portions of all the formations known in this portion of the West, however much they may have been fractured by upheaval, once extended across the broad interval.

Should we ascend the high pine-covered ridge on the north side of Trail Creek, we can look over into the next valley beyond, and along its northern side, extending west or northwest nearly to Fort Ellis, we can see the outcropping edges of the coal-beds, inclining north and northeast in wave-like ridges, until they die out about ten miles distant, from the reverse effect of the force which elevated the Crazy Woman Mountains. The Yellowstone River cuts directly through this ridge, and thus forms its first cañon, and the point of exit from the cañon is called the exit of the Yellowstone from the mountains. The walls on either side are entirely of Carboniferous rocks. The view from this ridge near the cañon, down the Yellowstone Valley to the Crow agency, is very instructive. Above the cañon the river flows nearly northward, but after emerging from the cañon it bends quickly around to the northeast and east, and enters a lower gorge, cutting through Tertiary and Cretaceous beds, about three miles below the mouth of Shield's River. This valley belongs to the old lake system; is oval in shape, expanding from one-fourth of a mile in width at the upper end to four or five miles. It is about ten miles in length and has an average width of three miles. On the left side of the Yellowstone, the somber-hued rocks of the Cretaceous and Eocene Tertiary groups present their basset edges like walls, and recede to the northwest and north, in step-like ridges, for ten or twenty miles. The thickness of these beds I could only estimate, and I believe them to be in the aggregate 1,500 to 2,000 feet in thickness. The inclination or dip varies much, sometimes 25° to 30°, then 10° to 20°. Just below the mouth of Shield's River, on the left side of the Yellowstone, there is a nearly vertical bluff of these beds, composed of alternate layers of sandstone and arenaceous clay, all with the steel-gray hue. The rocks are all of various textures and composition; some layers contain a considerable per cent. of clay, and the harder beds vary

in texture from a coarse sandstone to a compact homogeneous quartzite. There is in all the rocks a small per cent. of lime. The height of the bluff-like wall is about 500 feet, and on the summit there is an irregular bed of basalt, which fractures into an imperfect columnar form. In other localities layers of basalt are intercalated with the sedimentary beds, effecting greater or less changes in the contiguous rocks. Again, the basalt has flowed to the surface through the underlying strata, and spread over restricted areas. This group of rocks is remarkably well developed, and occupies nearly all the interval between the belt or ridge of limestone extending from near the junction of the Three Forks southwestward to the Yellowstone River and Shield's River. From the agency, this group extends down the Yellowstone as far as the eye can reach, so that there is a belt here of at least fifty miles from north to south, and twenty from east to west, which may be said to be almost entirely occupied by these beds, mingled with basaltic rocks which have been effused at different periods, and have been cooled under varying conditions. The same group of rocks appears on the right side of Gardiner's River, forming a bluff wall 800 to 1,200 feet high, with the same irregular beds of basalt. Similar steel-gray rocks occur in the Middle Park, containing leaves of deciduous trees, with thick beds of basalt, inclining at a high angle, in conformity with the Tertiary and Cretaceous beds. I have called these steel-gray beds Cretaceous and Tertiary, and yet I do not positively know that any portion belongs to the Tertiary. It is the group of rocks that contains the coal in this portion of the west. There are coal-beds near Fort Ellis, and indications of coal near the mouth of Shield's River on the Yellowstone. Leaves of deciduous trees of Tertiary affinities are abundant. No molluscan fossils were found, yet the character of the rocks and their great thickness leads me to believe that they are Upper Cretaceous, passing up without any physical line of separation into the Lower Tertiary. I think, also, that they form a part of the same group which contains the coal on the Lower Yellowstone, below the mouth of the Big Horn. These formations about the sources of the Missouri River and its branches need a much more careful and extended study than I have been able to give them, and I can only look forward into the future with hope, for time and opportunity to group them in their proper position.

The ridge of limestone which crosses the Yellowstone at the lower cañon seems, to one looking from the valley below, to rise abruptly out of the plains; the ridges, which are made up of the Jurassic, Cretaceous, and Tertiary groups, incline at various angles from the main ridge, and seldom rise above the general level more than 100 or 200 feet, while, at the base of the ridge, the upturned edges of the Lower Cretaceous and Jurassic rocks extend in long lines across the Yellowstone as far as the eye can reach, but not rising above the general level of the plain more than 50 or 100 feet, and sometimes not at all, but so covered with *débris* that they are only exposed in the channel of the Yellowstone. But the beds of limestone and quartzite of the Carboniferous group rise up 800 to 1,200 feet above the valley below, and though the inclination in the cañon is only about 15° to 30°, yet the outer beds dip 60° to 80°; this difference is not due to any want of conformability in the series, but doubtless to the greater ease with which the more modern beds have yielded to the erosive forces, while the Carboniferous limestones and quartzites have most effectually resisted those agencies. On the Yellowstone the lower ridges extend far to the northeast, with a somewhat irregular height, while the limestones are elevated so as to form a group of lofty peaks nearly as high as the volcanic cones of the snowy range,

9,000 to 9,500 feet above the sea. The northwest end of this Snowy Range is formed of roof-shaped peaks, with slopes toward the northwest, and summits running up like a wedge, easily distinguished by their shape from the more symmetrical basaltic peaks in the same range. Separated by an interval of about twenty-five miles to the northwest, there is a beautiful group of conical peaks, 9,000 to 10,000 feet high, occupying an area of not more than fifteen miles square, called Crazy Woman Mountains; I did not visit them, but I should judge that they might be a local upheaval on the same line of fracture with the Snowy Range. The two ranges are entirely separate, and each independent of any other, and surrounded by sedimentary formations which incline from their sides at various angles. The valley, or park, as it might be called, below the cañon, is extremely beautiful to the eye, as all these oval valleys are. The same proofs of an old lake basin, which we have before described, are seen everywhere, with gray and cream marls and sands, with great quantities of local drift, and the step-like terraces are well shown; there is a uniformity not only in the materials, but also in the deposition of them, which must show an intimate connection and a common origin. The cañon is about three miles long; the river has cut its way through the limestone ridge nearly at right angles, forming a perfect cross-section, so that the character of the rocks down to the granites may be examined. On the east side of the Yellowstone, a little above the cañon, the junction of the Carboniferous with the granitoid series may be seen with great clearness. There is no method that I could devise to arrive at the exact thickness of the Carboniferous group, but, with the aid of the best data I could secure, I estimated it at 1,500 to 2,000 feet. Where rocks are thrown up in such confusion, and the streams cut channels through mountains, forming cañons with vertical walls 1,000 to 1,500 feet, the grandeur of the operations will oftentimes produce such an effect on the mind as to lead to an exaggerated idea of the thickness, but my estimates have been checked so far as possible by the use of the barometer. Passing through the cañon, we came into a broad, open valley again, much larger but similar to one already described.

We may now return to the valley of Trail Creek. We have already stated that the range of hills on the left or north side of the valley is the ridge of limestone through which the Yellowstone River has carved out its lower cañon; the little stream, therefore, flows into the Yellowstone River just above the cañon. As we descend the valley of Trail Creek, we meet with a conspicuous isolated hill of basalt in the center of the valley, the east side bordering immediately on the valley of the Yellowstone. A minute description of this hill would apply to nearly all the volcanic phenomena of the Yellowstone Valley. It will be seen, therefore, that it is not only important, but necessary, to repeat the substance of many of our descriptions from time to time, in order to do any kind of justice to the subject. Basalt Butte is about 800 feet in height above the plains below, and overlooks the valley in every direction; it is evidently a huge mass cut off by Trail Creek Valley from the volcanic range on the south side. The *butte* is composed of volcanic conglomerate, or breccia; that is, the matrix is a steel-gray volcanic sand and dust, slightly calcareous, inclosing fragments of igneous rocks of varied character and texture. These inclosed masses vary in size from an inch to several feet in diameter; in most cases they are angular, and the aggregate I have called a breccia, but in this *butte*, and in some other localities, the masses are more or less rounded by attrition in water, showing that they have been transported some distance from

their origin. It is probable that the volcanic vent or point of effusion was from the group of volcanic cones, in the high range, on the east side of the Yellowstone, and that the dust, ashes, fragments of rocks, &c., were thrown out into the waters of the lake, and deposited and cemented into the apparently stratified condition they now present. The style of weathering is much the same as in ordinary conglomerates, and at this locality several gorges, which have been worn by water deep into the sides of the *butte*, show the strata to incline 5° to 15°. By examining the valleys of the streams and ravines on either side of the mountain ranges, we shall find upon what rocks, as a basis, this volcanic material rests. On the north side of Trail Creek, we have the limestone ridges full in view, the north side of the ridges sloping down into the plain below the cañon, while, on the south side, the edges of the limestone strata project up nearly vertically, in sharp pinnacles worn out by atmospheric forces. I think that these vertical limestones, for about four miles in extent along this creek, afford an illustration of the breaking down of the strata, like a table-leaf. Upon the plateau-like ridges above are remnants of the more modern beds, as red clays, Jurassic, Cretaceous, and the Coal Series. The latter have been lifted up by a force acting vertically. In the valley below are the outcropping edges of the limestones, inclining at a small angle, but in such a way as to carry them directly under the Basalt Butte. Indeed, the evidence is quite clear that, underneath the ranges of volcanic mountains on the west side of the Yellowstone, exists a part at least and possibly all the unchanged rocks known in this portion of the West. The effects of erosion are such all over this country, that we cannot assert the existence of the full series of sedimentary strata unless they are visible to the eye. From the summit of Basalt Butte the view is very beautiful and instructive. The valley of the Yellowstone, from the lower cañon, far up above Bottler's Ranch, to the second cañon, about thirty miles, has been the bed of one of the mountain lakes. On the east side of the Yellowstone the eye takes in at a glance one of the most symmetrical and remarkable ranges of mountains I have ever seen in the West. Several of my party who had visited Europe regarded this range as in no way inferior in beauty to any in that farfamed country. A series of cone-shaped peaks, looking like gigantic pyramids, are grouped along the east side of the valley for thirty or forty miles, with their bald, dark summits covered with perpetual snow, the vegetation growing thinner and smaller as we ascend the almost vertical sides, until, long before reaching the summits, it has entirely disappeared. On all sides deep gorges have been gashed out by aqueous forces cutting through the very core of the mountains, and forming those wonderful gulches which only the hardy and daring miner has ventured to explore. This range, which is called on the map Snowy Mountains, forms the great watershed between two portions of the Yellowstone River, above and below the first cañon, and gives origin to some of the most important branches of that river. Large numbers of springs and small streams flow down from the mountains into the Yellowstone on the southwest side. Below the first cañon, but from the northeast side, flow the Big Bowlder, Rosebud, Clark's Fork, and Pryor's Fork, with their numerous branches. This range continues on in a more or less broken condition to the southeast, until it connects with the Big Horn Range. From the summit of Emigrant Peak, one of the highest of these volcanic cones, one great mass of these basaltic peaks can be seen as far as the eye can reach, rising to the height of 10,000 to 11,000 feet above the sea. Emigrant Peak, the base of which is cut by the Yellowstone River, is 10,629 feet above tide-water, while the valley plain near Bottler's Ranch, on the op-

posite side of the river, was found to be 5,925 feet. This splendid group of peaks rises 5,000 feet and upward above the valley of the Yellowstone. This grand range of mountains ends abruptly in the bend of the Yellowstone, near the entrance of Shield's River, and the basset edges of the limestone strata, high up on the end and inclining to the northwest, show conclusively that, prior to their elevation, they extended uninterruptedly all over this region. The greater portion of the external surface of this range is compact basalt, but the cones or central portions are the granitoid rocks, in which the gold is found. Emigrant Gulch extends up into the mountains about eight miles. It is a deep, narrow gorge, with walls of a green and dark brown quartzite and true gneiss—indeed, the usual variety of metamorphic rocks distinctly stratified, a portion of them with so thin layers as to present a slaty appearance, and all with a somber-brown hue from contact with the igneous rocks. A fine stream of water flows swiftly down over its rocky bed into the Yellowstone. This gulch has been quite celebrated for some years past for its placer mines. It is estimated that somewhere from $100,000 to $150,000 in gold have been taken out since the discovery, in 1864. At one time there was quite a settlement, called Yellowstone City, near the entrance of the gulch, and the walls and chimneys of the houses are still standing. Probably two hundred or three hundred persons were engaged in washing for gold; some very fair lodes have been discovered near the head of the gulch. A large amount of money was expended at one time in sinking a shaft and digging a ditch for the purpose of reaching the "bed-rock." There are several other gulches on either side of Emigrant Gulch, extending up fifteen or twenty miles to the second cañon, and extending down to the lower or first cañon, all of which have yielded some gold. All these gulches cut through the basalt, deep into the granitoid nucleus, revealing the mineral character as well as the history of this range. They are not altogether formed by erosion, but were, of course, marked out during the process of upheaval; and as they have been the central lines of the erosive action of water in the far past, so they have been the reservoirs of the drainage from the snowy summits around, up to the present time. I thus take the position that during the upheaval of these mountain ranges, and perhaps since they have reached their present elevation, the aqueous forces were vastly more powerful than at present. The belt of land between the immediate base of the mountains and the channel of the Yellowstone varies from three to five miles in width, and is covered thickly with rounded bowlders, varying in size from a small pebble to several feet in diameter. The line of junction of the superficial deposits with the sides of the mountain, is such that this line of erosion is not unfrequently five hundred to six hundred feet above the bed of the Yellowstone, and is almost as well defined as a lake terrace. The little streams that flow down from the mountain sides cut sections through this deposit, so that they are revealed quite clearly. The upper portion is composed in part of *débris* from the mountains, but there is all over the valley a vast deposit of what I can call by no better name than local drift or detritus. In this detritus are quite frequently masses of rock or bowlders that have evidently been transported a considerable distance by a force not now in operation in the vicinity. This fact points back to a time when we may suppose that there were vast accumulations of snow and ice all over the valleys, but more especially on the sides and summits of the mountains; and as the temperature became much warmer, this snow and ice melted, producing rivers and torrents with sufficient force, aided perhaps by the masses of ice, to move these immense bowlders from place to place.

An important fact should be continually borne in mind, that a critical examination of this detritus reveals no evidence of the existence of rocks from any distant point outside of the river drainage in which they are found; in other words, these superficial deposits are entirely made up of the materials disintegrated from the rocks in the vicinity. The examination of this detritus is also important to determine the formations that may be sought for within the limits of that drainage. Underlying all this detritus, in this valley, is a greater or less thickness of the Pliocene deposits, and the little streams on their way to the main river show very distinctly where these sediments have been cast by the waters of the lake against the mountain sides. Not unfrequently some of the older unchanged rocks, or even the metamorphic strata, are exposed—remnants left after the great erosion which preceded the present period. The degradation of all kinds of rocks has been going on continually through all geological times, and the most important geological changes have thus been wrought. We may date back, first, to the time when all the formations known in the West, from the metamorphic rocks to the Eocene coal group, inclusive, extended uninterruptedly over the valley of the Yellowstone; and now only a few patches remain, here and there, of from 5,000 to 10,000 feet of sedimentary strata. Then, too, the mountain ranges have been pared down, we know not how much, since they began their upward movements to the present time. At any rate, we know that the erosion of the mountains has been immense; that, in many cases, entire ranges have been degraded, so that only fragments remain. Again, since this valley was a lake-basin, extensive degradation has taken place, removing a considerable thickness of the Pliocene deposits. It is only when they have been protected by a sheet of basalt, that we can form any correct idea of their original thickness. We may suppose this to be a good proof, from the fact that the basalts seem, in almost all cases, to have cooled under water at some depth, probably not great. At the upper portion of this valley, just below the second cañon, there are quite large areas covered with the Pliocene marls and sands, several hundred feet in thickness, overlaid with a thick floor of basalt. These Pliocene beds present the evidence of having been deposited in moderately quiet waters, so that we may suppose that they once extended all over the valley with a pretty uniform thickness. Since these valleys have been drained, or, perhaps, during the process of drainage, the surface has been worn into its present form, and the irregularities have been filled up with a greater or less thickness of local detritus.

It was doubtless during the slow process of drainage that the terraces, which constitute so conspicuous a feature of all these mountain valleys, were formed; these, also, were carved out of the Pliocene deposits. Sometimes these modern Tertiary beds are quite conspicuous, forming high vertical bluff walls along the valley. Again, they are removed, so that, with the exception of a narrow belt along the immediate base of the mountains on either side, the valley has been shaped into a low grass-covered lawn, but little raised above the bed of the stream. In many instances, as along the base of Emigrant Peak, the line of junction of the valley deposits with the sides of the mountain is indicated by the vegetation, and the descent, from that line down to the river bottom, is very gentle and smooth as a lawn, and covered with a thick growth of grass and other vegetation. This complete and gentle transition from mountain to valley forms one of the most striking and beautiful features in the landscape.

We will now proceed up the valley of the Yellowstone toward the

second cañon, noting, step by step, the principal features of interest. We have attempted to describe the lower cañon, the valley above as far as the mouth of Trail Creek, and the magnificent range of snow-mountains, of which Emigrant Peak forms a part. From the upper portion of the lower cañon to Trail Creek is about five miles; and from the mouth of Trail Creek to Bottler's Ranch, ten miles; and from the latter place to the second cañon, about twelve miles. We have stated that this valley was one of the lake-basins that formed a series of chain-like links extending probably throughout all the great hydrographic basins of the West. A little above Trail Creek, on the west side of the Yellowstone, there is an exposure of Carboniferous limestones, 200 to 300 feet thick, occupying only a small area, but enough to show that the sedimentary beds extend under the vast mass of basalt and breccia. On the road across the broad upland bottoms of the Yellowstone, a number of fine streams, six to ten feet wide, which have their origin in springs at the base of the range of mountains on the west side, flow across the table-like bottoms, almost on the surface, overflowing in many places, so that they form natural *acequias*. There is so little channel that they are quite noticeable. Basaltic bowlders of immense size are scattered all over the plain, and the finer detritus forms the covering of the entire surface. Some of these bowlders stand out in the plain far from any water at the present time, and are six to ten feet in diameter. It is possible that water alone has been the agent that has moved them to their present position, by slow degrees, at some period far back in the past, but it is also possible that ice may have aided in the work.

From the mouth of Trail Creek to Bottler's Ranch, the modern basalt makes its appearance on the west side of the valley from time to time. In some localities it is quite prominent and breaks off in regular columns. It is possible that this sheet or floor of basalt extended all over the valley at one time, as the appearance of the portions that are now left would seem to indicate. If so, the disintegration and removal of the basalt must have been very great. This basalt is visible in greater or less force all the way up to the foot of the second cañon, and on the east side of the Yellowstone there is a bluff wall, cut by the river, which shows, at the top at least, three different beds of basalt, indicating as many different outflows. Underneath the basalt are 100 to 150 feet of light-gray marly sand and sandstone, clearly belonging to the modern lake deposit. These are the rocks which may be said to form the valley proper—first, the Pliocene, or lake deposits; secondly, the broad sheet or floor of basalt; thirdly, the detritus, or local drift. On the sides of the main valley, and sometimes intrenching upon it, are the materials of the volcanic breccia, which must have been thrown out of fissures and vents in the mountain ranges on one side of the valley or the other, or perhaps both, into the waters of the lake, and then rearranged and cemented together. If we delay a moment, and study this basaltic breccia on the east side of the valley just back of our camp at Bottler's Ranch, we shall be able to form some conception of its character. We find here, that the foot-hills are entirely composed of it; and as the erosion has in some instances cut some excellent sections in it, it is easily studied. The general hue is the usual somber-gray or brown of most igneous rocks, but still there are a great variety of colors; sometimes there are thin seams of milky-white and cream marly clay, then a mixture of materials which, when disintegrated, leave *débris* like the ashes of an old furnace; at other places the rocks have a dull brick-red color, as if the volcanic fires had raged only yesterday. The whole as-

pect is modern, and one feels, as he winds his way among these high basaltic hills, that he is in a region where the great volcanic forces which have given form to this entire region, ceased at a period so recent, that a recurrence of the same events might be looked for at any time. Indeed, earthquake-shocks have been felt in the vicinity of Emigrant Gulch several times since the discovery of gold there in 1864. Immense masses of the basaltic breccia have fallen down from the mountains among the foot-hills; and in the valley some of the included masses are slightly worn, as if they had been rolled about in the waters for a time, but most of them are angular; some of them are red, like pumice, others black, compact, close in texture, like obsidian. There is, indeed, in this breccia almost every possible variety of basalt. The cement is rather firm, resisting the atmosphere well, looking much like volcanic ashes. Scattered through the bottoms and on the sides of the hills are quite abundant gneiss bowlders, some of them of great size, and most of them considerably worn.

From Fort Ellis to within a mile of the foot of the second cañon not an exposure of the metamorphic rocks was seen on the right or west side of our road; and, after leaving Trail Creek, the igneous rocks arose 2,000 to 2,500 feet above the valley, and some of the higher peaks were at least 3,000 feet above the plain As soon as we reach the foot of the second cañon, we find the mountains are made up of the same granitoid rocks. Two of the streams that flow down from the divide, that must have their sources at least ten or fifteen miles in the heart of the mountains west of the river, have brought down in their channels detached portions of the granitic rocks, showing that the central mass of the range between the second cañon and the sources of the west branch of the Gallatin is metamorphic. The size, abundance, and position of these rounded granite bowlders are such that no forces now in operation in this region could have moved them high up on the sides of the valley, where no water is found or can reach at the present time. They cover a space a mile in length and one-fourth of a mile in width, as thick as they can lie on the ground.

I have already referred to the section of the foot-hills cut by the Yellowstone River, about a mile above Bottler's Ranch, and that this section would seem to show the thickness and character of the original lake deposits. From the water up there is about one hundred feet of a light-cream marly, indurated clay, with some concretions, from a few inches to two feet in diameter. Above this there are 40 feet detritus, composed of rounded pebbles, and above this very modern local drift, there are 30 to 60 feet of the basalt. This fact shows the very modern character of this outflow, as I have endeavored to show in other portions of this report. Just opposite this bluff, on the west side of the valley, there is another feature which is quite a conspicuous one in the landscape. There is here a series of terraces, five in number, which rise, step by step, with remarkable regularity. The usual terrace system is undeveloped in this valley; but in this locality there is a series of regular steps, rising about 200 feet above the channel of the river. They probably belong to the system of terraces that was formed during the period of drainage of these mountain lakes; but why they should be divided in so marked a way as at this point I could not explain.

Before closing this chapter, I will note, very briefly, some of the resources of this valley. It is about fifteen miles long, and will average three miles in width; is well watered, soil fertile, and in every respect one of the most desirable portions of Montana. We may not look for any districts favorable for agriculture in the Yellowstone Valley above

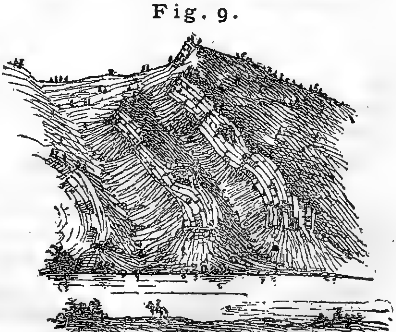
the second cañon; but this entire lake basin seems admirably adapted for grazing and for the cultivation of the usual crops of the country. The cereals and the roots have already been produced in abundance, especially wheat and potatoes. The mountains on either side are covered with snow, to a greater or less extent, all the year, which in melting, feeds the numerous little streams that flow down the mountain sides in the Yellowstone. Hundreds of springs flow out of the terraces. One terrace near Bottler's Ranch gives origin to fifty springs within a mile, and then, all aggregating together in the river bottom, form a large stream. Thus there is the greatest abundance of water for irrigation, or for any of the purposes of settlement. The elevation of the valley at this ranch is 4,925 feet, and this may be regarded as the average in altitude. But a small portion of it is occupied as yet, but the time is not far distant when the valley will be covered with fine farms and the hills with stock. It will always be a region of interest, from the fact that it is probably the upper limit of agricultural effort in the Yellowstone Valley.

CHAPTER IV.

FIRST CAÑON—SNOWY RANGE—EMIGRANT PEAK—BUTLER'S RANCH—SECOND CAÑON—DEVIL'S SLIDE—WHITE MOUNTAIN—HOT SPRINGS, &c.

In our last chapter we described the beautiful lake-basin below the second cañon. We found that rocks of volcanic origin predominated over all others. In this cañon, which is carved out of a lofty range of mountains by the river, we see that the core or nucleus is true gneissoid granite. Before reaching the cañon for a mile, the gneissic rocks are well shown high up on the mountain sides with a stratification so clear and distinct as to be a noticeable feature. The strata incline west 10° to 15°. The upper beds are composed mostly of feldspar and quartz, and are, consequently, compact and rather massive; but lower down they are a black, micaceous gneiss. About midway up the cañon the walls on either side rise up nearly vertically, on the east side 1,500 feet, and on the west side from 1,000 to 1,200 feet, the strata having a general dip of 30° to 40° westward. The different shades of color, give to the sides of the cañon a peculiarly stratified appearance, produced by alternate layers of micaceous granite, feldspar, and quartz. Protruding through the layers, here and there may be seen, as indicated by the dark hue, masses of trap, (Fig. 9.) Scattered all over the valley, and on the sides of the mountain, are great quantities of broken masses of granite. This cañon was undoubtedly started in a fissure, but it is mostly one of erosion. It is about three miles long. This is, of course, an extension of the range of mountains in which Emigrant Gulch is located, and it undoubtedly contains mines of gold. The rocks, with their peculiarly distinct and contorted strata as well as texture remind one of the gneissic mountains in the mining districts of Colorado. The river rushes with considerable force over the loose masses of rock

Fig. 9.



GNEISSIC STRATA, WITH TRAP.

that have fallen into the channel, and presents a picturesque view to the traveler struggling along over the narrow trail, high up on the mountain side. But wherever the water forms an eddy, so that it is even moderately quiet, the number of fine, large trout that can be taken out within a limited period would astonish the most experienced fisherman. Above the cañon the rocks return at once to their igneous character. This is readily shown by the difference in the appearance of the surface features. Although the granitic portion is higher and more massive in its general aspect, yet the surface is rounded and much of it covered with *debris* that admit the growth of grass, while the volcanic rocks give a jagged ruggedness to the outline. Outflows of dark-brown basalt, apparently of late date, mingled with huge masses of breccia, can be seen on either side of the valley to the summits of the mountains. The foot-hills on either side are certainly composed of breccia for several miles, which, decomposing, gives to the surface the appearance of the remains of an old furnace. Perhaps it would be better to compare it to a modern volcanic district. The *débris* has the great variety of colors peculiar to the remains of modern igneous action. The inclosed fragments are mostly angular, or slightly worn, and vary in size from minute particles to masses two feet in diameter, though they are mostly small. Some of the rounded hills are quite red on the summits, as if covered with cinders. The nuclei of the mountains are granite, however, although the basis rocks are mostly concealed by the outflows of volcanic material. On the east side, the river cuts close to the base of the mountains, but on the west side, there is quite a broad belt, comprising the foot-hills, which are composed of basaltic conglomerate, covered thickly with the *débris* of the same. There is here a small lake, 200 yards long and 50 yards wide, occupying a depression among the hills. The margins are covered with piles of volcanic *débris*, which give it the appearance of an old crater or fissure. The basaltic rocks rest upon the upturned edges of the metamorphic rocks, the former inclining in all directions, while the latter, on the west side of the river, dip west and northwest at all angles from 10° to a vertical side, while on the east side they incline east and southeast, at an angle of 60°. For a distance of two or three miles the mountains on the east side are so worn off that they present a vertical face, which reveals the inner character well. Alternate beds of a kind of somber indurated clay, volcanic *débris*, and basalt of various colors, continue all the way up for a thickness of several hundred feet. These rest upon a reddish feldspathic granite. In some places the melted basalt was poured over the surface of the granitic rocks, filling up the irregularities and penetrating the fissures so that it gives the sides of the mountains a mottled appearance. The volcanic and granitic rocks are mingled together in such confusion that it would require a long, tedious study to separate them. On the west side of the Yellowstone River, about ten miles above the second cañon, there is an exhibition of uplifted strata. It is sometimes called Cinnabar Mountain, from a brick-red band of clay which extends from the summit down the side, and was supposed to be cinnabar. A portion

Fig. 10.

CINNABAR MOUNTAIN.

of it, from its peculiarly rugged character, is called the "Devil's Slide." The lower part of the mountain facing the river is composed of light-

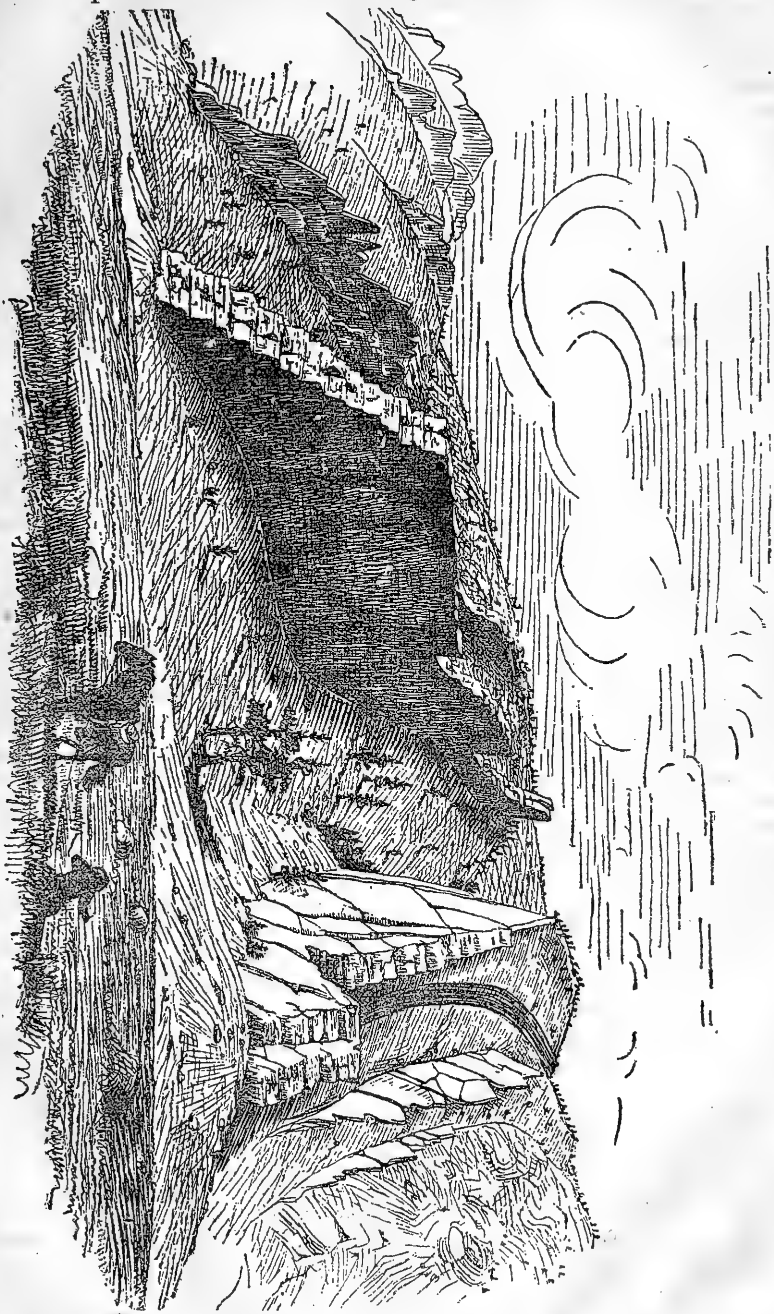


FIG. 11.

DEVIL'S SLIDE.

reddish feldspathic quartzites plainly metamorphic, and inclining at a high angle, (Fig. 10.) The valley is here about one-fourth of a mile wide, and

has evidently been cut through these quartzites. The same rocks underlie the mountains on the opposite side of the river, and resting unconformably on the quartzites are at least 1,000 feet of Carboniferous limestone, exceedingly cherty, impure, of a yellowish-gray and brown color, and so massive that the stratification is quite indistinct. These limestones possess a great variety of textures. Above them are a series of beds, standing in nearly a vertical position, alternating with clays which have been worn away by atmospheric forces, so that the harder layers project above the surface in jagged edges. The harder layers are mostly yellowish cherty limestones. The band of indurated brick-red clay is 50 to 100 feet thick, and from its bright scarlet hue attracts the attention of travelers from all points of the compass. A bed of yellowish-gray quartzite forms one of the walls of the Devil's Slide, and is probably near the summit of the Carboniferous group in this locality. The excellent illustration, (Fig. 11,) taken on the spot by Mr. Elliott, shows the nearly vertical wall of quartzite on the right, the broad interval covered with *débris*, grass, and a few scattered pines; and on the left, the huge wall or dike of basalt. The low interval is composed of dark steel-gray slate, extends from the summit to the base of the hill, and is about 150 feet wide. The south wall or dike is very compact trachyte, stands nearly vertical, 50 feet thick, and at some points 200 feet high. It is probable that this igneous mass was thrust up between the strata, since they were elevated to their present position, and doubtless during the Pliocene period. On either side of the dike, the clays have been changed into the metamorphic slates. Fragments of the slate are attached to the walls high up on either side. This is a remarkable feature in the geology of this region. Far to the left or south of the dike the jagged vertical edges of the Jurassic strata can be seen. The inclination of all these beds ranges from 60° to 80° southwest. The two walls of the Devil's Slide stand at an angle of 80°. The interval near the summit of the hill is rather narrow, but expands out at the base to double the width. Above this dike, in order of superposition, though now standing side by side, is a group of Jurassic strata—first, a low interval of shaly, marly clay, ashen brown; secondly, brownish-gray arenaceous limestone, with fragments of fossils that are evidently Jurassic, 50 feet thick; dip, 70°; thirdly, purplish and reddish indurated, slaty clay, with seams of sandstone projecting but little above the surface; fourthly, a bed of trap 6 feet thick; fifthly, slaty clay sandstones, the upper part a fine pudding-stone, standing nearly vertical, 70° to 80°, 100 feet; sixthly, numerous layers, which may be aggregated as alternate beds of yellowish-gray quartzites and slaty clays, varying but little in texture, the harder portions standing up in more or less jagged edges, with the softer clays washed out from between them; dip, 60° to 70; 300 feet; seventhly, 200 feet of ashen-gray shales and sandstones; eighthly, 400 to 600 feet of alternate beds of shaly clay sandstone and quartzites. This last group doubtless contains the Lower Cretaceous beds. The harder layers, 6 to 10 feet thick, rise above the general surface of the mountain-side like walls. The dip is 50° to 60°. The dark laminated clays of the Cretaceous passing up into the Upper Cretaceous are well shown with perfect continuity, then passing up into a great thickness of somber brown sandstones of the Coal group. There is a great uniformity in the Upper Cretaceous and Tertiary series. We can detect some variations in color and texture, but they are of minor importance, and could not be easily described in words. At one point the strata are much crushed together. The dip of the beds just described is toward the southeast; but, by the elevation of the mountain to the

southeast, the inclination of the Lower Tertiary and Cretaceous beds is reversed northwest 15° to 25°, extending to the summits of the mountains, which rise 3,000 feet above the Yellowstone River, and are capped with Carboniferous limestones.

From the general appearance of the surface of the country, I believe that there was originally much greater uniformity in the inclination of the sedimentary strata, in the aggregate, than there is at present. The volcanic forces which operated at a period subsequent to the elevation of the older sedimentary beds rendered their position much more chaotic in many localities. We have here, within a few miles, the Carboniferous beds, near the channel of the Yellowstone, and the same strata capping a mountain-peak 3,000 feet above it. We have also, in the exposure here and there of a consecutive series of the sedimentary beds, continual proofs of our statement that they originally extended all over the area now occupied by the valley and the mountain ranges that border it.

The study of the series of sedimentary rocks, so finely exposed at Cinnabar Mountain and with such regularity of sequence, reveals another interesting fact—that the Yellowstone Valley may be, in part at least, one of anticlinal origin. We have before shown that the limestone range contracted to a narrow belt near Fort Ellis and Bozeman Pass; that near the head of Trail Creek the ridge seemed to divide, the north portion of the anticlinal crossing the Yellowstone River at the Lower Cañon, and continuing a little south of east along the sources of the branches of the Yellowstone, as Big Bowlder, Rosebud, Black's Fork. The south portion extended southward along the western side of the dividing range between the drainage of the Yellowstone and the Missouri Rivers. Cinnabar Mountain seems therefore to represent a fragment of the south portion, which has not been concealed by *débris* or volcanic outflow, or removed by erosion.

About four miles above Cinnabar Mountain the basalt seems to have poured out over the entire surface, and forms mountain-peaks, rising 2,000 to 2,500 feet above the valley. In the sides of some of the foot-hills are exposed from 100 to 300 feet of strata nearly or quite horizontal, and apparently modern—not older than Pliocene—sands, sandstones, and marly clays, overlaid by beds of basalt. They have the dark-brown hue which all the modern rocks seem to have when contiguous to igneous outflows. From Cinnabar Mountain to the mouth of Gardiner's River, about six miles, the Yellowstone Valley, which expands out on the west side to a width of about two miles, is covered with rounded bowlders of massive granite. The mica is usually black, so that the granites have a somber hue somewhat like ancient trap. The channel of the river is also filled with these huge bowlders, which have probably been brought down from the cañon of the Yellowstone opposite Gardiner's River. Just above Cinnabar Mountain, on the east side of the Yellowstone, the more modern beds make their appearance low down on the sides of the mountains, as if the dip of the sedimentary rocks had changed toward the east, and the channel had cut through the intervals of the ridges, exposing the outcropping edges of about 800 feet of Tertiary beds of various colors and textures. They are filled with intrusions of basalt. The sides of the hills are covered with the dark *débris*. Bear Gulch is a deep, narrow cañon, which the little stream has cut into the mountain side, exposing the granitic core. Masses of granite have been wrenched from their parent bed and swept down into the valley of the Yellowstone.

The third cañon is mostly through the granites. They are, as usual,

of a great variety of textures, but largely massive feldspar. Between the Yellowstone and Gardiner's River, commencing at the junction, a wedge of land commences, which rises to the height of 2,000 feet or more with great regularity. This is a portion of the belt of modern sedimentary beds, as shown on the east side of the river, below the junction, as exposing an outcropping thickness of about 800 feet. The Yellowstone makes a bend to the eastward at this point, running outside of the belt of sedimentary strata, and carving its channel out of granitic and volcanic rocks. The latter are composed of basalt, basaltic conglomerate, and the deposit of Hot Springs. Gardiner's River, although diverging but little from a parallel, seems to flow through a monoclinal interval, exposing a clean, wall-like front of 1,200 feet, on the east side, of Cretaceous and Tertiary strata. The dip is slight, 10°, but toward the northeast, and as we ascend the river, lower beds are exposed, until at least 1,800 feet of Cretaceous and Lower Tertiary beds are brought to the surface within a distance of six or eight miles. Local intercalated beds of basalt are also exposed toward the summit of the hill, and near the forks of the river a heavy bed of the basalt, quite compact, rests horizontally on the inclined edges of the strata. There were found here quantities of obscure fossils, among them a species of *Ostrea*, and a number of impressions of deciduous leaves, all of Cretaceous affinities. At another locality a layer of shells was found, and among them Mr. Meek detected *Corbula pyriformis*, a species occurring near Bear River City, which is regarded as of estsary origin, and of Tertiary age. At another point I found upon the side of the hill, on the east fork of Gardiner's River, *Amonites*, *Baculites*, and *Inoceramus*. There is little or no lime in this great group of beds, simply alternate beds of sandstone, arenaceous clays, passing down into the dark somber clays of the Cretaceous. As we descend in the series, the rocky layers diminish, and the indurated clays increase, until near the forks of Gardiner's River, the dark Cretaceous clays are 500 feet thick. The sides of the bluff hill are deeply furrowed. This inner ridge, which we have just attempted to describe, is one of the finest exposures, as a vertical section of strata, that I have met with in this portion of the West. These beds are only a remnant of a former period, isolated monuments covering a very restricted area; whereas they must have extended across the river, and all over the portion now occupied by the mountains to the westward of the sources of the Missouri. The lower beds of the Cretaceous with the Jurassic and the Carboniferous inclusive, incline from the east side of the mountains, and dip under Gardiner's River. It is through the latter beds that the waters of the White Mountain Hot Springs come to the surface. Just above the junction of Gardiner's River with the Yellowstone, on the east side, a seam of earthy lignite six inches thick crops out. Below it is a layer of oyster-shells, and above it are impressions of deciduous leaves. The local detritus all over this valley is so extensive that it deserves continual notice. It seems to fill up the irregularities of the surface, especially in the vicinity of the streams. The section made by the river reveals 50 to 100 feet at times, filling up old ravines or gulches worn out of the basis rocks.

Before proceeding further with the general geological features of this country, I will attempt to describe, with as much detail as possible, one of the most remarkable of the many marvels of this wonderful valley.

I have just described, with some minuteness, the high wall of Cretaceous and Tertiary beds on the east side of Gardiner's River, which, in itself, is well worthy of careful attention. Upon the opposite side of the river, on the slope of the mountain, is one of the most remarkable

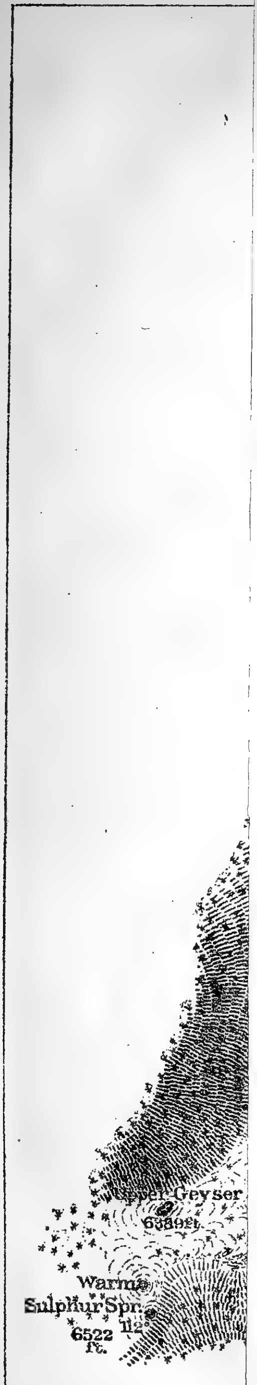

Geyser
Warme
Sulphur Spr.
112°
6522
ft.

Fig. 12.

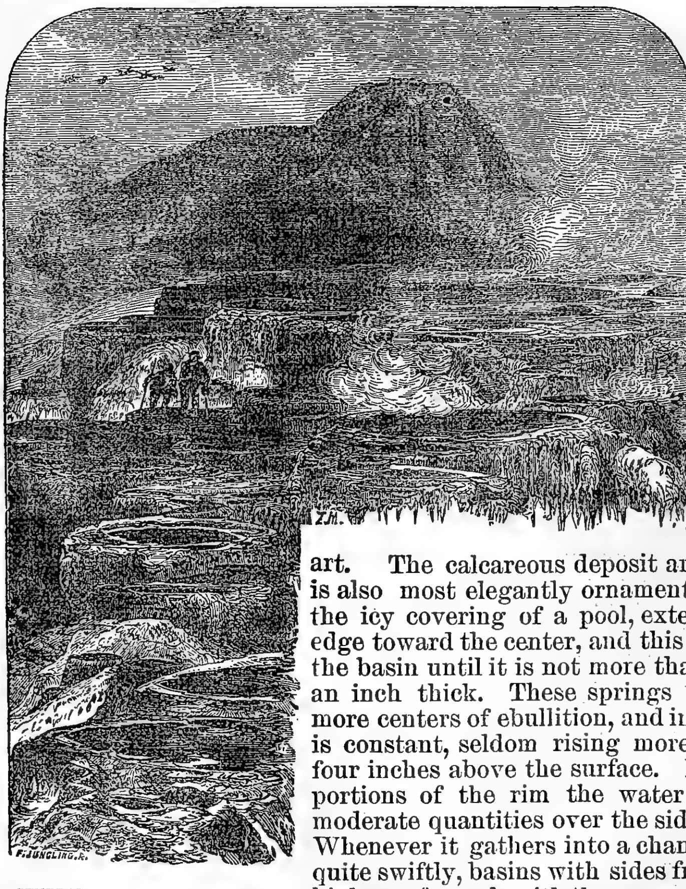
WHITE MOUNTAIN HOT SPRINGS, GARDINER'S RIVER, 1871.

groups of hot springs in the world. The springs in action at the present time are not very numerous or even so wonderful as some of those higher up in the Yellowstone Valley or in the Fire-Hole Basin, but it is in the remains that we find so instructive records of their past history. The calcareous deposits from these springs cover an area of about two miles square, (see chart, Fig. 12.) The active springs extend from the margin of the river 5,545 feet to an elevation nearly 1,000 above, or 6,522 feet above the sea by barometrical measurement. We may commence our description at the springs near the margin of Gardiner's River. As we pass up the valley from the junction of Gardiner's River with the Yellowstone, we see all over the sides of the hills upon our left the *débris* of volcanic rocks mingled with the Cretaceous clays. Indeed, the entire surface looks much like the refuse about an old furnace. The tops of the rounded hills are covered with the fragments of basalt and conglomerate, and the great variety of somber colors adds much to the appearance of desolation. One or two depressions, which appear much like volcanic vents, are now filled with water to the rim, forming stagnant lakes fifty to one hundred yards in diameter. We pass over this barren elevated region, 200 to 400 feet above the river-bed, for two miles, when we descend abruptly to the low bottom, which is covered with a thick calcaereous crust, indicating the former existence of hot springs. At one point a large stream of hot water, 6 feet wide and 2 feet deep, flows swiftly along its channel from beneath the crust, the open portion of the channel clearly revealed by the continual steam arising. The temperature varies from 126° to 132°. On the 28th of August the temperature was 130°, and about the 15th of July previous it was 126°. There is a greater quantity of water flowing from this spring than from any other in this region. A little farther above are three or four other springs near the margin of the river. These have nearly circular basins 6 to 10 feet in diameter, and do not rise above 100° to 120°. Around these springs are gathered, at this time, a number of invalids, with cutaneous diseases, and they were most emphatic in their favorable expressions in regard to the sanitary effects. The most remarkable effect seems to be on persons afflicted with syphilitic diseases of long standing. Our path led up the hill by the side of a wall of lower Cretaceous rocks, and we soon came to the most abundant remains of old springs, which, in past times, must have been very active. The steep hill, for nearly a mile, is covered with a thick crust, and, though much decomposed and covered with a moderately thick growth of pines and cedars, still bore traces of the same wonderful architectural beauty displayed in the vicinity of the active springs farther up the hill. After ascending the side of the mountain, about a mile above the channel of Gardiner's River, we suddenly came in full view of one of the finest displays of nature's architectural skill the world can produce. The snowy whiteness of the deposit at once suggested the name of White Mountain Hot Spring. It had the appearance of a frozen cascade. If a group of springs near the summit of a mountain were to distribute their waters down the irregular declivities, and they were slowly congealed, the picture would bear some resemblance in form.

We pitched our camp at the foot of the principal mountain, by the side of the stream that contained the aggregated waters of the hot springs above, which, by the time they had reached our camp, were sufficiently cooled for our use. Before us was a hill 200 feet high, composed of the calcareous deposit of the hot springs, with a system of step-like terraces which would defy any description by words. The

eye alone could convey any adequate conception to the mind. The steep sides of the hill were ornamented with a series of semicircular basins, with margins varying in height from a few inches to 6 or 8 feet, and so beautifully scalloped and adorned with a kind of bead-work that the beholder stands amazed at this marvel of nature's handiwork. Add to this, a snow-white ground, with every variety of shade, of scarlet, green, and yellow, as brilliant as the brightest of our aniline dyes. The pools or basins are of all sizes, from a few inches to 6 or 8 feet in diameter, and from 2 inches to 2 feet deep. As the water flows from the spring over the mountain side from one basin to another, it loses continually a portion of its heat, and the bather can find any desirable temperature. At the top of the hill there is a broad flat terrace covered more or less with these basins, one hundred and fifty to two hundred yards in diameter, and many of them going to decay. Here we find the largest, finest, and most active spring of the group at the present time. The largest spring is very near the outer margin of the terrace and is 25 by 40 feet in diameter, the water so perfectly transparent that one can look down into the beautiful ultramarine depth to the bottom of the basin. The sides of the basin are ornamented with coral-like forms, with a great variety of shades, from pure white to a bright cream-yellow, and the blue sky reflected in the transparent waters gives an azure tint to the whole which surpasses all art. The calcareous deposit around the rim is also most elegantly ornamented, but, like the icy covering of a pool, extends from the edge toward the center, and this projects over the basin until it is not more than a fourth of an inch thick. These springs have one or more centers of ebullition, and in this group it is constant, seldom rising more than two to four inches above the surface. From various portions of the rim the water flows out in moderate quantities over the sides of the hill. Whenever it gathers into a channel and flows quite swiftly, basins with sides from 2 to 8 feet high are formed, with the ornamental designs proportionately coarse, but when the water

Fig. 13.

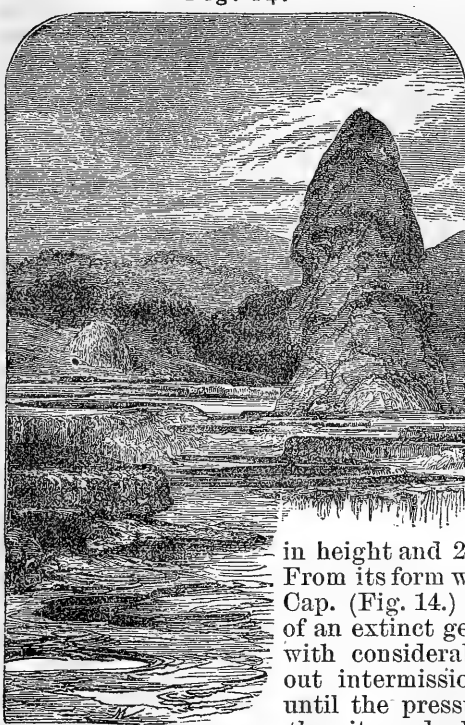


GENERAL VIEW OF OVERFLOW OF GREAT SPRING, GARDINER'S RIVER.

flows slowly, myriads of the little basins are formed, one below the other, with a kind of irregular system, as it might be called, which constitutes the difference between the works of nature and the works of art. The water holds a great amount of lime in solution. It also contains some soda, alumina, and magnesia. The ebullition is largely due to the emission of large quantities of carbonic acid gas. As these waters flow down the sides of the mountain, they constantly deposit more or less of this calcareous sediment in almost every possible variety of form. Underneath the sides of many of these pools are rows of stalactites of all sizes, many of them exquisitely ornamented, formed by the dripping of the water over the margins of the basins. The annexed illustrations will convey some idea of the form of these bathing-pools as they are arranged one above the other, but the beautiful series of photographs taken by Mr. Jackson are of far greater value. Even the photograph, which is so remarkable for its fidelity to nature, falls far short. It fails to give the exquisitely delicate contrasts of coloring which are so pleasing to the eye. (Fig. 13.)

On the west side of this deposit, about one-third of the way up the White Mountain from the river and terrace, which was once the theater of many active springs, old chimneys, or craters, are scattered thickly over the surface, and there are several large holes and fissures leading to vast caverns beneath the crust. The crust gives off a dull hollow sound beneath the tread, and the surface gives indistinct evidence of having been adorned with the beautiful pools or basins just described. As we pass up to the base of the principal terrace, we find a large area covered with shallow pools, some of them containing water with all the ornamentations perfect, while others are fast going to decay, and the decomposed sediment is as white as snow. Upon this kind of sub-terrace is a remarkable cone about 50 feet in height and 20 feet in diameter at the base. From its form we gave it the name of the Liberty Cap. (Fig. 14.) It is undoubtedly the remains of an extinct geyser. The water was forced up with considerable power, and probably without intermission, building up its own crater until the pressure beneath was exhausted, and then it gradually closed itself over at the summit and perished. No water flows from it at the present time. The layers of lime were deposited around it like the layers of straw on a thatched roof or hay on a conical stack. Not far from the Liberty Cap is another small cone, which, from its form, we called the "Bee-hive." These springs are constantly changing their position; some die out, others burst out in new places. A fine large spring made its appearance for the first time in August last on this terrace. On

Fig. 14.

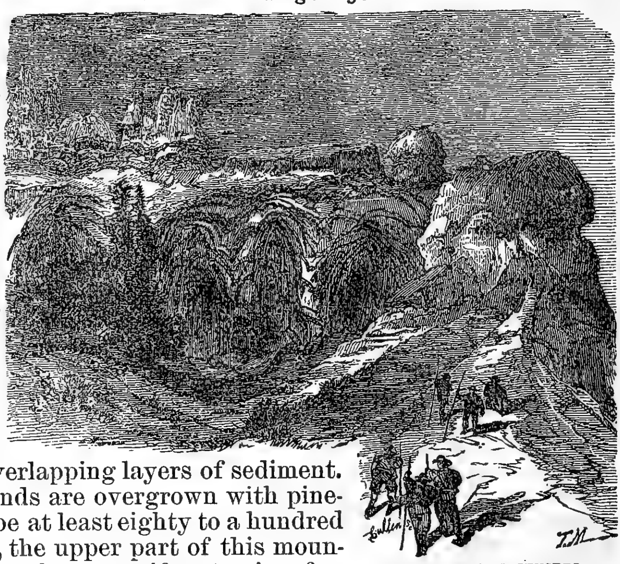


LIBERTY CAP.

the northwest margin of the main terrace there is an example of what I have called an oblong mound. There are several of them here, extending in different directions, from fifty to one hundred and fifty yards in length, from 6 to 10 feet high and from 10 to 15 feet broad at the base. There is in all cases a fissure from one end of the summit to the other, usually from 6 to 10 inches wide, from which steam sometimes issues in considerable quantities, and as we walk along the top we can hear the water seething and boiling below like a cauldron. The inner portion of this shell, as far down as we can see, is lined with a hard, white enamel-like porcelain; in some places beautiful crystals of sulphur have been precipitated by the steam. These have been built up by a kind of oblong fissure-spring in the same way that the cones have been constructed. The water was continually spouting up, depositing sediment around the edges of the fissure until the force was exhausted, and then the calcareous basin was rounded up something like a thatched roof by overlapping layers.

Near the upper terrace, which is really an old rim, are a number of these extinct, oblong geysers, some of which have been broken down so as to show them to be a mere shell or cavern, which is now the abode of wild animals. (Fig. 15.) I attempted to enter one of them, and it was full of sticks and bones which had been carried in by wild beasts, and swarms of bats flitted to and fro. Some of them have been worn away so that sections are exposed, showing the great number and thickness of the overlapping layers of sediment. Some of these mounds are overgrown with pine-trees, which must be at least eighty to a hundred years old. Indeed, the upper part of this mountain has the aspect of a magnificent ruin of a once flourishing village of these unique structures, now fast decomposing, even more beautiful and instructive in their decay. We can now study the layers of deposit, which are sometimes revealed by thousands on a single mound, as we would the rings of growth of a tree. How long a period is required to form one of these mounds, or to build up the beautiful structure which we have just described, I have not the data for determining. Upon the middle terrace, where the principal portion of the active springs are at the present time, some of the pine-trees are buried in the sediment apparently to the depth of 6 or 8 feet. All of them are dead at the present time. We have evidence enough around the springs themselves to show that the mineral-water is precipitated with great rapidity. I think I am safe in believing that all the deposits in the immediate vicinity of the active springs are constantly changing from the margin of the river to the top of the White

Fig. 15.

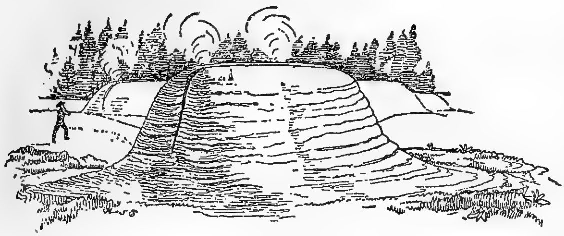


EXTINCT OBLONG GEYSERS.

Mountain and return. The deposits upon the very summit are great, though now there is very little water flowing from the springs, and that is of a low temperature.

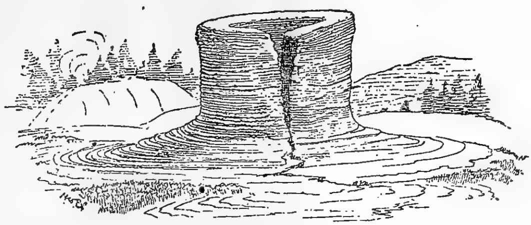
Traces of even greater activity than we see at present are found in some localities, and it is more than probable that the force is gradually dying out from year to year, and that finally it will cease entirely. We have numerous localities in the West where there have been vast groups of hot springs and geysers, but at the present time only the ruins are left. It would seem probable that the heat which gives the temperature to the atmospheric waters rises through numerous fissures from one common source in the interior of the earth, so that when from some cause this heat is checked in its upward progress in one place, it finds vent in another, and thus passes from point to point over a district. It is probable that they have existed since the period of volcanic activity, and that now they are diminishing in force, and that eventually nothing but the deposit will remain. Large numbers of old chimneys are scattered over the surface, formed by what may be properly called pulsating geysers. (Figs. 16 and 17.)

Fig. 16.



CHIMNEY, GARDINER'S RIVER.

Fig. 17.



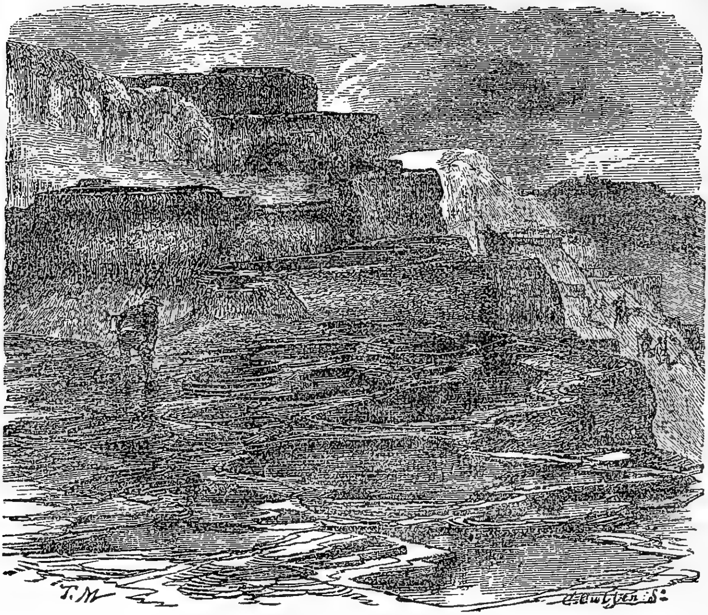
DEAD CHIMNEY, GARDINER'S RIVER.

Between one of the largest oblong mounds and the base of the upper terrace, there is a kind of a valley-like interval, which has once been the center of much activity, but at the present time there are numerous small jets from which the water is thrown to the height of 2 to 4 feet. But it is to the wonderful variety of exquisitely delicate colors that this picture owes the main part of its attractiveness. The little orifices from which the hot water issues are beautifully enameled with the porcelain-like lining, and around the edges a layer of sulphur is precipitated. As the water flows along the valley, it lays down in its course a pavement more beautiful and elaborate in its adornment than art has ever yet conceived. The sulphur and the iron, with the green microscopic vegetation, tint the whole with an illumination of which no decoration-painter has ever dreamed. From the sides of the oblong mound, which is here from 30 to 50 feet high, the water has oozed out at different points, forming small groups of the semicircular, step-like basins. (Fig. 18.)

Again, if we look at the principal group of springs from the high mound above the middle terrace, we can see the same variety of brilliant coloring. The wonderful transparency of the water surpasses anything of the kind I have ever seen in any other portion of the world. The sky, with the smallest cloud that flits across it, is reflected in its clear depths, and the ultramarine colors, more vivid than the sea, are greatly heightened by the constant, gentle vibrations. One can look down into

the clear depths and see, with perfect distinctness, the minutest ornament on the inner sides of the basins; and the exquisite beauty of the coloring and the variety of forms baffle any attempt to portray them,

Fig. 18.



BATHING POOLS, WHITE MOUNTAIN HOT SPRINGS.

either with pen or pencil. And then, too, around the borders of these springs, especially those of rather low temperature, and on the sides and bottoms of the numerous little channels of the streams that flow from these springs, there is a striking variety of the most vivid colors. I can only compare them to our most brilliant aniline dyes—various shades of red, from the brightest scarlet to a bright rose tint; also yellow, from deep-bright sulphur, through all the shades, to light cream-color. There are also various shades of green, from the peculiar vegetation. These springs are also filled with minute vegetable forms, which under the microscope prove to be diatoms, among which Dr. Billings discovers *Palmella* and *Oscillara*. There are also in the little streams that flow from the boiling springs great quantities of a fibrous, silky substance, apparently vegetable, which vibrates at the slightest movement of the water, and has the appearance of the finest quality of cashmere wool. When the waters are still these silken masses become incrusted with lime, the delicate vegetable threads disappear, and a fibrous, spongy mass remains, like delicate snow-white coral. Although these springs are in a constant state of violent ebullition at different points in the basin, yet it will be seen on the chart that the temperatures are far below boiling-point, the highest being 162°. Owing to the thinness of the rim of the basin, and the heat from the steam, it was impossible to take the temperature except at the edges, and by no means at the hottest portion; and the violent ebullition is undoubtedly due in part to the evolution of carbonic acid gas. It is quite possible that the thermometer would have indicated the boiling-point (which at this elevation is about 194°) if it could have been placed in one of these centers of

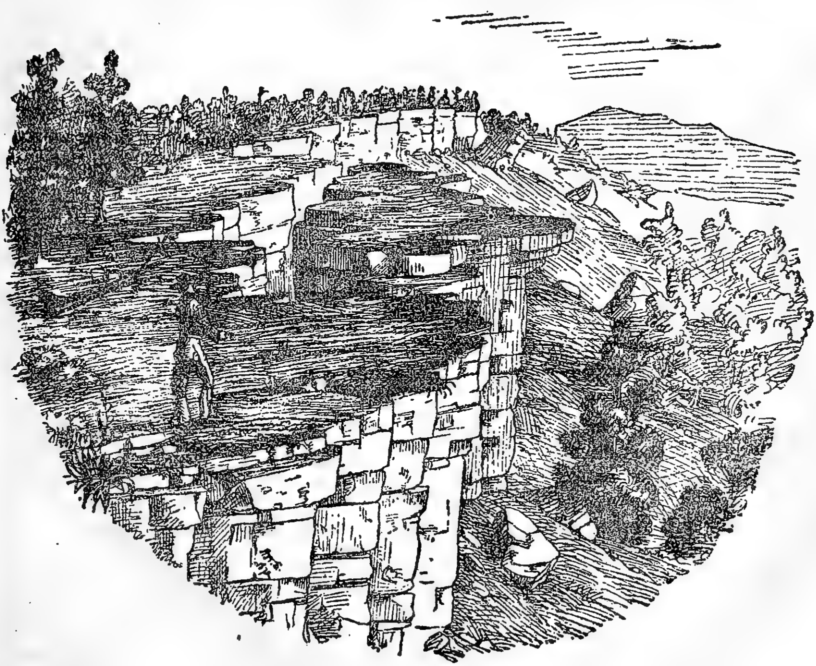
ebullition. The grotto in the glen, (Fig. 19,) is a fine illustration of the beautiful decorations, and along the channels of the streams that flow from the vivid coloring is well displayed. From the summit the stream is continually arising from a number of vents, each one of which is lined with sulphur. Quantities of steam are ever ascending from the springs, but on a damp morning the entire slope of the mountain is enveloped in clouds of vapor.

Fig. 19.

GROTTO IN THE GLEN, WHITE MOUNTAIN HOT SPRING.

The question of the antiquity of these springs is one of great interest, and yet, with all the evidence before us, it is somewhat obscure. Upon the margins of the mountain, high above the present position of the hot springs, is a bed of very white or yellowish-white limestone, 50 to 150 feet thick, and appearing in the distance like very pure Carboniferous limestone. (Fig. 20.) It is regularly stratified, and the jointing is complete, and immense masses have fallen down on the slope of the mountain side. There is a belt a mile long and one-fourth of a mile wide, covered with

Fig. 20.



OLD HOT SPRING. LIMESTONES SHELVING OFF BY FROST, ETC.

immense cubical blocks of the limestone 50 to 100 feet in each dimension,

usually with the wedge-shaped end projecting upward, as if the mass had slowly fallen down as the underlying rocks were worn away by erosion. So thickly is this belt covered with these huge masses that it is with the greatest difficulty one can walk across it. It would seem that this bed must at one time have extended over a portion or all of the valley of Gardiner's River. Much of the rock is very compact, and would make beautiful building-stone, on account of its close texture and color, and it could be converted into the whitest of lime. If the rocks are examined, however, over a considerable area, they will be found to possess all the varieties of structure of a hot-spring deposit. Some portions are quite spongy, and decompose readily; others are made up of very thin laminæ, regular or wavy; enough to show the origin of the deposit without a doubt. But in what manner was it formed? I believe that the limestone was precipitated in the bottom of a lake, which was filled with hot springs, much as the calcareous matter is laid down in the bottom of the ocean at the present time. Indeed, portions of the rock do not differ materially from the recent limestones now forming in the vicinity of the West India Islands. The deposit was evidently laid down on a nearly level surface, with a moderately uniform thickness, and the strata are horizontal. Since this group of strata was formed, the country has been elevated to some extent at least, and the valley of Gardiner's River has been carved out, so that the commencement of the period of activity of these springs must date back to a period merging on to, but just prior to, the present, probably at the time of the greatest action of the volcanic forces.

We may now ask why these deposits are mainly calcareous, and what is the source of the lime.

I have already given a brief account of the geological formations in the immediate vicinity. On the side of Gardiner's River, opposite the hot springs, there is a bluff wall extending about six miles, composed of 150 feet in the aggregate of Upper Cretaceous and Lower Tertiary strata, with some irregular intercalated beds of basalt. The river itself flows through a sort of monoclinal interval; that is, the bluff wall just alluded to is formed of the outcropping edges of the strata, while on the opposite side or slope the lower beds incline in the same direction. Near the river some of the lower beds are Cretaceous, but they soon pass to the Jurassic and Carboniferous; on the east side of the springs are beds of arenaceous limestone full of Jurassic fossils. We can then see that the vast thickness of Tertiary and Cretaceous strata once extended across Warm Spring Creek, over the slope of the mountain occupied by the hot-spring deposit, and, probably, westward across the vast divide into the Missouri Valley. We have, also, clear proof that, underneath this calcareous deposit, there is at least a thickness of 1,500 feet of Carboniferous limestone.

If the origin of the heat which so elevates the temperature of the waters of these springs is as deep-seated as is generally supposed, then the heated waters have ample play for their power in dissolving the calcareous rocks beneath. There are several localities in the valley of the Yellowstone where the deposits are calcareous, but most of them are unimportant, and the springs themselves have entirely disappeared. If we divide the springs according to the character of their deposits, we shall find that there are two principal classes—those in which lime predominates, and those which have an excess of silica; or calcareous and siliceous springs. We shall present this subject more fully in a subsequent portion of this report.

In figure 21 I have attempted to present an ideal section of the strata

on Gardiner's River. Upon the summit of the Tertiary and Cretaceous strata, at the right, is a bed of basalt. While passing by, under the river and beneath the calcareous deposit of the springs, are the Carboniferous limestones; beneath all, we suppose, there is a great thickness of trachyte. We may also suppose that the meteoric waters pass up to the surface through the limestone, as shown in the section, cleaving the lime that is deposited on the way. This subject will be discussed more fully in a future report.

We have already spoken of the wedge-like ridge between the Yellowstone and Gardiner's Rivers, and the wall of Cretaceous Tertiary, and basaltic strata facing the hot-spring district. These consist of alternate beds of dark-brown clays and somber-gray sandstone, some portions thinly laminated or compact like quartzite; inclination, east 10°. These beds extend up in their full force about three miles above the springs on the east side of the East Fork, where they become obscured by basaltic rocks and detritus. Masses of basalt have fallen down from the summit of the ridge into the valley below, in many instances obstructing the current and rendering traveling difficult. About a mile above the springs, Gardiner's River separates into three branches, which we may call East, Middle, and West Forks. They take their rise high up in the divide that separates the lake basin from the valley below. I have estimated the length of these

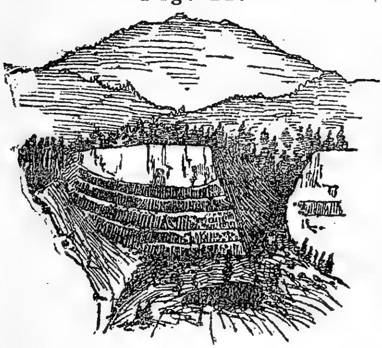
Fig. 21.

IDEAL SECTION WHITE MOUNTAIN HOT SPRINGS, GARDINER'S RIVER.

forks to be fifteen miles each. As we ascended the high ridge between the East and Middle Forks, we obtained a fine view of the surrounding country. Far to the southwest are fine lofty peaks covered with snow, and rising to the height of 10,000 feet. They form a part of the magnificent range of mountains that separates the Yellowstone from the sources of the Gallatin. From this high ridge we can look down into the chasm of the Middle Fork, which is carved out of the basalt and basaltic conglomerates to the depth of 500 to 800 feet, with nearly vertical sides. In the sides of this cañon, as well as those of the East Fork, splendid examples of basaltic columns are displayed, as perfect as those of the celebrated Fingal's Cave. They usually appear in regular rows, vertical, five and six sided, but far more sharply cut than any I have ever seen in the West. Sometimes there are several rows, one above the other, with conglomerate between, usually about fifty feet high. Sometimes, however, these columns are spread out fan-like, as is shown in the figure. (Fig. 22.)

The top of the cañon is about 500 yards from margin to margin, but narrowing down until on the bottom it is not more than forty yards wide. At one point the water pours over a declivity of 300 feet or more, forming a most beautiful cascade. The direct fall is over 100 feet. The constant roar of the water was pleasant to the ear, and reminded us most strongly of a train of cars in motion. The pines are very dense, usually of moderate size, and among them are many open spaces, which are covered with stout grass, sometimes with large sage-bushes. Upon the high mountain hills the vegetation is remarkably luxuriant, indicating great fertility of soil. The detritus is usually very thick, and covers a great portion of the surface, and this is made up mostly of degraded igneous rocks. Above the falls the rows of vertical columns continue in the walls of the cañon, and they may well be ranked, with great fitness, among the remarkable wonders of this rare wonder-land. The lower portion of the cañon is composed of rather coarse igneous rocks, which have a jointage and a style of weathering like granite.

Fig. 22.



BASALT AT LOW FALLS ON GARDINER'S RIVER.

South of the hot springs we ascended a round dome-like mountain, which rises 2,100 feet above them. From the summit we could look from thirty to fifty miles in every direction. To the north and west of us a group of lofty peaks were very conspicuous—over 10,000 feet above the sea, and covered with huge masses of snow. These peaks form a part of the range that separates the waters of the Gallatin from those of the Yellowstone. Farther on to the southward are the peaks of the head of the Madison, and in the interval one black, undulatory mass of pine, with no point rising over 8,500 feet above the sea. These might be called high plateaus, more or less wavy or rolling, interspersed here and there with beautiful lakes a few hundred yards in diameter; and here and there a bright-green grassy valley, through which the little streams wind their way to the large rivers. In one of these lakes we saw the greatest abundance of a yellow water-lily like *Nuphar advena*. On the east side of Gardiner's Cañon, and west of the Yellowstone, is a sort of wave-like series of ridges, one after the other, with broad, open, grassy inter-

spaces, with many groves of pines. These ridges gradually slope down to the Yellowstone, northeast. Far to the east and north is one jagged mass of volcanic peaks, some of them snow-clad, others bald and desolate to the eye. Far to the south, dimly outlined on the horizon, may be seen the three Tetons and Madison Peak—monarchs of all the region. A grander view could not well be conceived. The summits and sides of the mountain are thickly covered with fragments of dull-brown basalt; but what seemed most strange were the rounded masses of black, very compact basalt, mingled with the less compact angular fragments, broken from the mountain side. How did these huge bowlders reach these lofty summits? They are not numerous, and, at the present time, the proofs of water having covered these mountain tops since they have attained their present elevation are not clear. It is quite possible they were lodged there prior to the period of its elevation.

The three forks of Gardiner's River rise high up in the mountains, among the perpetual snows. They wind their way across a broad plateau covered mostly with a dense growth of pines, but with broad, open, meadow-like spots, which can be seen clearly from some high mountain peak, and lend a charm to the landscape. After gathering a sufficient supply of water, they commence wearing their channels down into the volcanic rocks, which continue to grow deeper as they descend. Each one has its water-fall, which would fill an artist with enthusiasm. The West Fork rolls over a bed of basalt, which is divided by jointage into blocks that give the walls the appearance of mason-work on a gigantic scale. Below the falls the river has cut the sides of the mountain, so that we can see a vertical section 400 feet high, with the same irregular jointage.

After exploring the Middle and West Forks we climbed up the steep sides of the cañon of the East Fork, passed the picturesque cascade and basaltic columns, and finally reached the summit of the ridge which separates the cañon from Gardiner's River. The highest point of the ridge is 450 feet above the bed of basalt that forms the margin of the east wall of Gardiner's River. Beds of sandstone are here mingled with basalt in dire confusion. From this ridge the third cañon is well shown. Among the ridges of sandstone and basalt, are several pretty lakes from two hundred to four hundred yards in length. These little lakes are really expansions of the drainage, and are usually in the synclinal troughs. East of the summit of the ridge the sedimentary beds assume a reversed dip from the mountains on the east side of the Yellowstone. We find, therefore, the Jurassic arenaceous limestones and sandstones, and the limestones of the Carboniferous, near the margins of the cañon. On the summit of the ridge the basalt is quite coarse, and decomposes into a kind of sandy clay. I can only give a general idea of the geology of this region. The chaos is so great that it would occupy one entire season to unravel the singular structure, and then the results would be so meager of profit or instruction that they would be most unsatisfactory. The real thought involved in it is not difficult to abstract. The third cañon is formed partly by erosion and partly by upheaval, and the rocks which compose its walls are granitic and igneous. The basis rocks are the granitoid, while filling up the irregularities of the surface are the volcanic materials of various kinds. The same may be said of the lofty, rugged range of mountains on the east side of the river. A group of volcanic peaks of varied forms filled up the broad interval between the Yellowstone and the sources of the Big Horn. They vary in height from 9,500 to 10,000 feet above the sea, and are grouped without the least regularity. The peaks themselves do not seem to be connected together

along any line or axis of elevation, but each one, like a group of hot springs, seems to have been a volcanic vent which built up its own cone. The igneous rocks have been poured out over the metamorphic, plainly at different periods. The general mineral character of the igneous material is about the same, but the colors and textures are very variable; some of them are coarse, decomposing easily; others rough, angular, vesicular, or compact; some red, purple, brown, black, &c. The study of the immense masses of basaltic conglomerate which cover the country everywhere, especially in the upper basin, affords the best opportunities of ascertaining the different varieties of the igneous rocks in the country, for fragments of all kinds seem to have been included in the volcanic paste.

After leaving Gardiner's River we ascended the broad slope of the dividing ridge between that river and the little branches that flow into the Yellowstone. Below and above the entrance of the East Fork, immense bowlders of massive granite, considerably rounded, are a marked feature. One of them, partially rounded by water, is 25 feet thick and 50 feet long, with a fracture directly through the middle. It is a massive red feldspathic granite. The ridge of Carboniferous limestone, which is exposed on the west margin of the third cañon, extends up in fragments for six or eight miles. It is very brittle and cherty. The high wavy ridge, which is about 9,000 feet above the sea, is composed of beds of steel-gray and brown sandstone, clays, and a calcareous clay, with numerous impressions of deciduous leaves; vast quantities of silicified wood of greatest perfection and beauty are scattered all over the surface. Some quite long trees and stumps were observed by the party. The layers of growth were as perfectly shown as in any of our recent woods. Upon the summit of the ridges or hills were beds of basalt as usual. We have, then, a chaos here which it would be impossible to unravel, except by tracing the formations from far distant points in their continuity. The detritus is so thick and upon this grows such a luxuriant vegetation, either grass or dense forests of pine, that the sedimentary rocks are exposed only here and there over restricted areas. We know, however, that up to the Grand Cañon, and up the East Fork, for fifteen miles, the Carboniferous, Jurassic, Cretaceous, and Tertiary groups are represented more or less, although we can only catch glimpses of them at rare intervals. We were traveling through this region in the latter part of the month of July, and all the vegetation seemed to be in the height of its growth and beauty. The meadows were covered densely with grass, and flowers of many varieties, and among the pines were charming groves of poplars, contrasting strongly by their peculiar enlivening foliage with the somber hue of the pines. The climate was perfect, and in the midst of some of the most remarkable scenery in the world, every hour of our march only increased our enthusiasm.

The climate during the months of June, July, and August, in this valley, cannot be surpassed in the world for its health-giving powers. The finest of mountain water, fish in the greatest abundance, with a good supply of game of all kinds, fully satisfy the wants of the traveler, and render this valley one of the most attractive places of resort for invalids or pleasure-seekers in America.

We will now descend the ridge in the more immediate valley of the Yellowstone near the entrance of the East Fork, and not far from the lower end of the Grand Cañon. Our road is a rough one. The sedimentary rocks were crumpled into high, sharp, wave-like series of ridges. From innumerable fissures, the igneous matter was poured out over the surface which cooled into basalt; and from these vents was also thrown out, into the great lake, fragments and volcanic dust, which were arranged

by the water and cemented into a breccia. Deep into these ridges the little streams have cut their channels in past ages, forming what should be called valleys, rather than cañons, with almost vertical sides, with rocks cropping out here and there, covered mostly with grass or trees. These ravines, 500 to 800 feet deep, occur one after the other in great numbers, many of them entirely dry at present, but attesting the presence and power of aqueous forces at no very remote period in the past, compared with which those of the present are utterly insignificant.

Not until surface geology receives greater attention than it has done up to this time will we comprehend the vastness of the agencies which have wrought out the wonderful results which we see everywhere around us. What were the forces that wrenched from the parent bed masses of granite, from one ton to five hundred tons weight, rounded off the angles and lodged them upon the plains 300 to 500 feet above the channels of the principl astreams? Along the East Fork, for twenty miles above its mouth, on the west side, there is a sort of terrace about a mile in width, literally covered with the granite bowlders which have been swept down the valley from a short distance above. The granitic rocks, of various textures and composition, are here exposed in full force. Hell-Roaring Mountain, at the entrance of the creek of that name, is a huge peak composed of stratified gneiss. Some of the strata, however, are 50 to 100 feet in thickness, massive red or gray feldspathic granite. Just opposite the entrance of the stream there is a splendid exhibition of black micaceous gneiss, inclining 14° southeast. It seems to form a vertical wall on the right side of a little creek that flows into the Yellowstone from the west, while on the left side the entire mass of the hills, for miles in extent, is composed of the usual variety of igneous rocks. These incline in the opposite direction, northwest, 10° to 15°; so that this small stream, now not more than 4 feet wide and 6 inches in depth, has, at some period, had sufficient power to cut its channel two hundred to four hundred yards wide, through the hardest rocks, 500 to 1,000 feet in depth, to the level of the Yellowstone, into which it flows. Hell-Roaring River is quite a large stream, rising high in the dividing range to the east, and flowing with tremendous impetuosity down the deep gorges, thus receiving its peculiar name. The mountains on either side are among the most rugged in the Yellowstone country, and seem to defy access. They come close down to the channel of the Yellowstone on the east side, so that traveling on that side is attended with great difficulty. On the west side the broad, high, irregular, step-like terrace, or rather group of foot-hills, 300 to 800 feet above the bed of the Yellowstone, is quite easily traversed, and a road for wagons could be made without much labor. There are some steep hills which, at the present time, appear formidable, but a careful exploration might bring to light a route that would avoid them mostly.

After crossing the high divide, between the drainage of Gardiner's River and the group of little streams that flow into the Yellowstone on the west side, of which Tower Creek is the most conspicuous, we come to the region of wonderful ravines and cañons. Layers of basalt have been poured out over the basis rocks, of whatever age they may be, at different periods; at the same time vast quantities of fragments of basalt were cemented together with a fine volcanic dust. In the process of wearing out the ravines and cañons on either side, hundreds of curious pinnacles and columns, resembling groups of Gothic spires, were carved out of the solid beds of basalt and breccia. On the east side of the Yellowstone, the sides of the mountain rise step-like, and, at different elevations, the basalt has poured out and overflowed like the deposits of hot springs, except that the deposit is a dingy-black color. These out-

flows seem to be so modern that it is doubtful if any important changes have taken place in the surface since they occurred. The river flows over its narrow rocky bed with great velocity. The East Fork enters the Yellowstone on the east side through a narrow granite cañon, and is a stream of considerable magnitude. In the spring season the quantity of water must be great, for the area drained by it is at least forty by twenty miles, where the snow falls in large quantities and remains a large portion of the year. About four miles above, Tower Creek enters the Yellowstone. On the west side, just at the lower end of the Grand Cañon, within a few yards, is the mouth of Hot Spring Creek. Along the shores, the hot water is oozing and boiling up through the soft mud, covering the surface with its peculiar deposits; one of the springs has a temperature of 127°. A strong smell of sulphuretted hydrogen pervaded the atmosphere. The banks of the Yellowstone, on both sides, for thirty to fifty feet up from the water's edge, have a most peculiar whiteness, with yellow portions, due to the deposits of old hot springs, which were very abundant here at some period. The few springs that remain are full of sulphuretted and carbonated hydrogen, forming a black carbonaceous matter on the surface at times. There is also free sulphur, carbonate of lime, carbonate of iron, &c. It seems quite possible that the Carboniferous limestones do not exist beneath the basalts in this region, from the fact that there is not any great amount of calcareous sediment. High up on the mountains, on the east side of the Yellowstone, 9,500 feet, there is a bluff wall of limestone like that near Warm Spring River, evidently the same white compact rock formed from deposits of hot springs probably during or near the close of the Pliocene period. Tower Creek rises in the high divide between the valleys of the Missouri and Yellowstone, and flows about ten miles through a cañon so deep and gloomy that it has very properly earned the appellation of the "Devil's Den." (Fig. 23.) As we gaze from the margin down into the depths below, the little stream, as it rushes foaming over the rocks, seems like a white thread, while on the sides of the gorge the somber pinnacles rise up like Gothic spires. About two hundred yards above its entrance into the Yellowstone the stream pours over an abrupt descent of 156 feet, forming one of the most beautiful and picturesque falls to be found in any country. The Tower Falls are about

Fig. 23.

DEVIL'S DEN, TOWER CREEK.

260 feet above the level of the Yellowstone at the junction, and they are surrounded with pinnacle-like columns, composed of the volcanic breccia, rising fifty feet above the falls and extending down to the foot, standing like gloomy sentinels or like the gigantic pillars at the entrance of some grand temple. One could almost imagine that the idea of the Gothic style of architecture had been caught from such carvings of nature. Immense bowlders of basalt and granite here obstruct the flow of the stream above and below the falls, and although, so far as we can see, the gorge seems to be made up of the volcanic cement, yet we know that, in the loftier mountains, near the source of the stream, true granitic as well as igneous rocks prevail.

In the walls of the lower end of the Grand Cañon, near the mouth of Tower Creek, we can see the several rows of columns of basalt arrayed in a vertical position, and as regular as if carried and placed in the sides of the gorge by the hand of art. There is upon the surface a bed of volcanic breccia, then a row of vertical columns, then the cement with hot spring deposits, then another row of columns. There are at least three different series of the columns, while above and below to the edge of the water are the volcanic and hot spring deposits. In the tongue that runs down between the junction of the East Fork and the Yellowstone, there is a singular *butte* cut off from the main range, which at once attracts the traveler's attention. The basis or lower portion of the *butte* is granite, while the summit is capped with the modern basalt, and the *débris* on the sides and at the base is remarkable in quantity, and has very much the appearance of an anthracite coal-heap. This *butte* will always form a conspicuous landmark, not only on account of its position, but also from its peculiar shape and structure. Just below the junction of the East Fork, a bridge was constructed across the Yellowstone about a year ago, to accommodate the miners bound for the "diggings" on Clark's Fork. It was evidently built with a considerable amount of labor and boldness, for the river flows with great rapidity along the narrow, rocky channel, and is about 200 feet in width. I make mention of this bridge in this connection from the fact that it is the first and only one as yet which has been erected across the Yellowstone River, and may in the future assume some historical importance.

On the west side of the Yellowstone and west of Tower Falls, the basalt is quite massive, sometimes forming columns quite irregular in form and length, differing much from those on the opposite side. The benches and irregular step-like terraces along the Yellowstone on both sides, which are quite picturesque, are formed in part by the sliding down of masses of earth from the margins of the cañon. In the immediate valley there is a recent drift deposit of sand and bowlders, often stratified, made at a long period subsequent to the carving out of the main channel through the volcanic rocks. The stratification and fineness of the sediment would indicate still water, or moderately so, at least.

Soon after leaving Tower Creek, our road diverged to the westward of the Yellowstone River and crossed the northern side of the rim of the basin proper, about a mile west of Mount Washburn, the highest peak in this portion of the range. We followed a well-worn path up the northern side, which led us up a slope so gentle that we were able to ride our horses to the very summit. The ground is everywhere covered with fragments of basalt and conglomerate, and at one locality there was an abundance of fine specimens of chalcedony with malachite, (green carbonate of copper.) The volcanic rocks of this region contain some fine specimens of mineral forms, of which silica is the base. There are grades of exquisite beauty. Agates are common.

The view from the summit of Mount Washburn is one of the finest I have ever seen, and although the atmosphere was somewhat obscured by smoke, yet an area of fifty to one hundred miles radius in every direction could be seen more or less distinctly. We caught the first glimpse of the great basin of the Yellowstone, with the lake, which reminded one much, from its bays, indentations, and surrounding mountains, of Great Salt Lake. To the south are the Tetons, rising high above all the rest, the monarchs of all they survey, with their summits covered with perpetual snow. To the southwest an immense area of dense pine forests extends for one hundred miles without a peak rising above the black, level mass. A little farther to the southwest and west are the Madison Mountains, a lofty, grand, snow-capped range, extending far to the northward. Nearer and in full view, to the west commence the bold peaks of the Gallatin Range, extending northward as far as the eye can reach. To the north we get a full view of the valley of the Yellowstone, with the lofty ranges that wall it in. Emigrant Peak, and the splendid group of mountains of which it is a part, can be clearly seen, and lose none of their marvelous beauty of outline, view them from what point we may. To the north and east the eye scans the most remarkable chaotic mass of peaks of the most rugged character, apparently without system, yet sending their jagged summits high up among the clouds. Farther distant are somewhat more regular ranges, snow-covered, probably the Big Horn. But with all this magnificent scenery around us from every side, the greatest beauty was the lake, in full view to the southeast, set like a gem amid the high mountains, which are literally bristling with peaks, many of them capped with snow. These are all of volcanic origin, and the fantastic shapes which many of them have assumed under the hand of time, called forth a variety of names from my party. There were two of them that represented the human profile so well that we called them the "Giant's Face" and "Old Man of the Mountain." These formed good landmarks for the topographer, for they were visible from every point of the basin.

Mount Washburn is composed entirely of the usual igneous rocks. On the summits are piles of very hard, compact basalt, cleaving into laminæ, or in irregular blocks. All around on the sides of the mountain are immense accumulations of the usual volcanic breccia. The central mass was originally a volcanic cone, building up a crater with the compact basalt, but throwing out in the surrounding or enveloping waters the fragments or dust which were cemented together all around on the sides, sometimes reaching very nearly to the summit. On the southeast side of the mountain a distinct anticlinal interval or opening is seen in the breccia. The south side inclines east 25°, and breaks off abruptly near the Grand Cañon, while the opposite side dips west 20°. Between this anticlinal and the cañon there is a bench five hundred feet below the summit of the mountain, which, I am convinced, formed the inner portions of the old crater, while the breccia composed the outer walls. To the southeast there is a grassy plateau ten to twenty miles in extent, immediately surrounded with dense forests of pine. We may say, in brief, that the entire basin of the Yellowstone is volcanic. I am not prepared to pronounce it a crater, with a lake occupying the inner portion, while the mountains that surround the basin are the ruins of this great crater; but, at a period not very remote in the geological past, this whole country was a scene of wonderful volcanic activity. I regard the hot springs so abundant all over the valley as the last stages of this grand scene. Hot springs, geysers, &c., are so intimately connected with what we usually term volcanoes that their origin and action

admit of the same explanation. Both undoubtedly form safety-valves or vents for the escape of the powerful forces that have been generated in the interior of the earth since the commencement of our present period; the true volcanic action has ceased, but the safety-valves are the thousands of hot springs all over this great area. I believe that the time of the greatest volcanic activity occurred during the Pliocene period—smoke, ashes, fragments of rock, and lava poured forth from thousands of orifices into the surrounding waters. Hundreds of cones were built up, fragments of which still remain; and around them were arranged by the water the dust and fragments of rock, the *ejectamenta* of these volcanoes, in the form of the conglomerate or breccia as we find it now. These orifices may have been of every possible form—rounded or oblong, mere fissures, perhaps, extending for miles, and building up their own crater rims as the hot springs build up their rounded, conical peaks or oblong mounds at the present time. It is not necessary to enter into the history and origin of either hot springs or volcanoes in this connection. The causes which have produced the phenomena here, either in the Pliocene period or the present, are the same all over the world, and have been favorite topics of discussion by men of science.

CHAPTER V.*

THE GRAND CAÑON—FALLS—HOT SPRINGS—YELLOWSTONE LAKE.

We will now enter upon a description of the Yellowstone Basin proper, in which the greater portion of the interesting scenery and wonders is located. The term is sometimes applied to the entire valley, but the basin proper comprises only that portion inclosed within the remarkable ranges of mountains which give origin to the waters of the Yellowstone south of Mount Washburn and the Grand Cañon. The range of which Mount Washburn is a conspicuous peak seems to form the north wall or rim, extending nearly east and west across the Yellowstone, and it is through this portion of the rim that the river has cut its channel, forming the remarkable falls and the still more wonderful cañon. The area of this basin is about forty miles in length. From the summit of Mount Washburn, a bird's-eye view of the entire basin may be obtained, with the mountains surrounding it on every side without any apparent break in the rim. This basin has been called by some travelers the vast crater of an ancient volcano. It is probable that during the Pliocene period the entire country drained by the sources of the Yellowstone and the Columbia was the scene of as great volcanic activity as that of any portion of the globe. It might be called one vast crater, made up of thousands of smaller volcanic vents and fissures, out of which the fluid interior of the earth, fragments of rock, and volcanic dust were poured in unlimited quantities. Hundreds of the nuclei or cores of these volcanic vents are now remaining, some of them rising to a height of 10,000 to 11,000 feet above the sea. Mounts Doane, Langford, Stevenson, and more than a hundred other peaks may be seen from any high point on either side of the basin, each of which formed a center of effusion. Indeed, the hot springs and geysers of this region, at the present time, are nothing more than the closing stages of that wonderful period of volcanic action that began in Tertiary times. In other words, they are the escape-pipes or vents for those internal forces which once were so active, but are now continually dying out.

* An abstract of Chapters V and VI was published in the February and March numbers of the American Journal of Science.

The evidence is clear that ever since the cessation of the more powerful volcanic forces these springs have acted as the escape-pipes, but have continued to decline down to the present time, and will do so in the future, until they cease entirely. The charts accompanying this report will enable the reader to form a clear conception of the position and number of the most important springs in this basin, but an equal number of the dead and dying have been omitted. We may therefore conclude that the present system of hot springs and geysers is only a feebler manifestation of those remarkable internal forces of the earth, which were so wonderfully intensified during the periods of volcanic activity, that they really present for our study a miniature form of *volcanism.* Even at the present time there are connected with them manifestations of internal heat and earthquake phenomena which are well worthy of attention. While we were encamped on the northeast side of the lake, near Steamboat Point, on the night of the 20th of July, we experienced several severe shocks of an earthquake, and these were felt by two other parties, fifteen to twenty-five miles distant, on different sides of the lake. We were informed by mountain-men that these earthquake shocks are not uncommon, and at some seasons of the year very severe, and this fact is given by the Indians as the reason why they seldom or never visit that portion of the country. I have no doubt that if this part of the country should ever be settled and careful observations made, it will be found that earthquake shocks are of very common occurrence.

Our trail passed over the rim of the basin on the south side of Mount Washburn, and the lowest point was 8,774 feet. In crossing this divide or rim, I saw, on the north side, some of the somber argillaceous sandstones that contain the deciduous leaves between Gardiner's River and Tower Creek. After passing the "divide" we descended the almost vertical sides of the rim into the valley of Cascade Creek, at the level of 7,787 feet, or about 1,000 feet below the "divide." Our trail was a tortuous one, to avoid the fallen timber and the dense groves of pine. The country immediately around the creek looked like a beautiful meadow at this season of the year, (July 25,) covered with grass and flowers. Cascade Creek flows from the west into the Yellowstone, between the upper and lower falls. Just before it enters the Yellowstone, it flows over a series of ridges and breccia, making one of the most beautiful cascades in this region; hence the name of the little stream. Like all these rapids or falls, it is formed of the more compact basalt, resisting the wear of the atmospheric forces, while the breccia readily yields. As this little cascade is seen from the east branch of the Yellowstone, dividing up into a number of little streams and rushing down from ledge to ledge until it reaches the bed of the river, it presents a picture of real beauty. High up on Cascade Creek, almost a mile above its mouth, the channel is carved out of a kind of sedimentary volcanic sandstone, arranged in regular strata; most of it is so largely made up of worn fragments of obsidian and other igneous rocks that it might be called a pudding-stone. The natural sections in the channel of this creek aid us much in forming an idea of the extent of the modern lake deposit, which doubtless began in Tertiary times, and continued on up into or near the present period. The surface everywhere is covered with fragments of volcanic rocks, apparently quite modern, so that it presents that peculiar appearance, which I have often alluded to, like the refuse about an old foundry.

But the objects of the deepest interest in this region are the falls and the Grand Cañon. I will attempt to convey some idea by a de-

scription, but it is only through the eye that the mind can gather anything like an adequate conception of them. As we approached the margin of the cañon, we could hear the suppressed roar of the falls, resembling distant thunder. The two falls are not more than one-fourth of a mile apart. Above the Upper Falls the Yellowstone flows through a grassy, meadow-like valley, with a calm, steady current, giving no warning, until very near the falls, that it is about to rush over a precipice 140 feet, and then, within a quarter of a mile, again to leap down a distance of 350 feet. Before proceeding further with a detailed description of the falls and cañon, I may attempt to present what I believe to be the origin. For about a mile above the Upper Falls there is a succession of rapids in the river. The walls of the channel are not high, but are composed of massive basalt. Just along the Upper Falls there are five huge, detached blocks of basalt in and near the center of the channel. These show the force with which the water has rushed down the channel at some period. Just above the Upper Falls are two beautiful cascades, 20 to 30 feet high, and at the east one, the rocks so wall in the channel that it is not much more than 100 feet wide, and the entire volume of the water, which must form a mass 100 feet wide and 30 feet deep, rushes down a vertical descent of 140 feet. There seems to have been a sort of a ridge or belt of very compact basalt that extended across the channel, so hard as to resist successfully atmospheric power, while below, the nearly vertical walls, which are composed of clay, sand, and bowlders, mingled with hot-spring deposits, seem to have readily yielded, and thus the river has carved out its channel. From any point of view the Upper Falls are most picturesque and striking. The entire volume of water seems to be, as it were, hurled off of the precipice with the force which it has accumulated in the rapids above, so that the mass is detached into the most beautiful snow-white, bead-like drops, and as it strikes the rocky basin below, it shoots through the water with a sort of ricochet for the distance of 200 feet. The whole presents in the distance the appearance of a mass of snow-white foam. On the sides of the basalt walls there is a thick growth of vegetation, nourished by the spray above, which extends up as far as the moisture can reach. The upper portion of the walls of the cañon on the east side is composed of a coarse volcanic sandstone and pudding-stone, perfectly horizontal, and below are loose variegated clays and sands. There is no doubt that this deposit forms a part of the bed of the ancient lake in its enlarged extent, and that this deposit was made on the rugged, irregular basalt surface. In the mean time, there were occasional outflows of igneous matter, and the hot springs were operating in full force. The lake basin was closed at the lower end of the range of mountains that form the rim, and the river gradually forced its way through this rim, forming the Grand Cañon, draining the lake basin, and the falls were the result. There is all around the basin a sort of secondary shore in the form of a group of low, pine-covered hills, varying in height from 8,500 to 9,000 feet above the sea, while the highest ranges, 10,000 to 11,000 feet, constitute the primary rim. The lower hills are made up mostly of the old lake deposit, and are either Pliocene or Post-Pliocene, probably both.

But no language can do justice to the wonderful grandeur and beauty of the cañon below the Lower Falls; the very nearly vertical walls, slightly sloping down to the water's edge on either side, so that from the summit the river appears like a thread of silver foaming over its rocky bottom; the variegated colors of the sides, yellow, red, brown, white, all intermixed and shading into each other; the Gothic columns of every form standing out from the sides of the walls with greater

variety and more striking colors than ever adorned a work of human art. The margins of the cañon on either side are beautifully fringed with pines. In some places the walls of the cañon are composed of massive basalt, so separated by the jointage as to look like irregular mason-work going to decay. Here and there a depression in the surface of the basalt has been subsequently filled up by the more modern deposit, and the horizontal strata of sandstone can be seen. The decomposition and the colors of the rocks must have been due largely to hot water from the springs, which has percolated all through, giving to them the present variegated and unique appearance.

Standing near the margin of the Lower Falls, and looking down the cañon, which looks like an immense chasm or cleft in the basalt, with its sides 1,200 to 1,500 feet high, and decorated with the most brilliant colors that the human eye ever saw, with the rocks weathered into an almost unlimited variety of forms, with here and there a pine sending its roots into the clefts on the sides as if struggling with a sort of uncertain success to maintain an existence—the whole presents a picture that it would be difficult to surpass in nature. Mr. Thomas Moran, a celebrated artist, and noted for his skill as a colorist, exclaimed with a kind of regretful enthusiasm that these beautiful tints were beyond the reach of human art. It is not the depth alone that gives such an impression of grandeur to the mind, but it is also the picturesque forms and coloring. Mr. Moran is now engaged in transferring this remarkable picture to canvas, and by means of a skillful use of colors something like a conception of its beauty may be conveyed. After the waters of the Yellowstone roll over the upper descent, they flow with great rapidity over the apparently flat rocky bottom, which spreads out to nearly double its width above the falls, and continues thus until near the Lower Falls, when the channel again contracts, and the waters seem, as it were, to gather themselves into one compact mass and plunge over the descent of 350 feet in detached drops of foam as white as snow; some of the large globules of water shoot down like the contents of an exploded rocket. It is a sight far more beautiful, though not so grand or impressive as that of Niagara Falls. A heavy mist always arises from the water at the foot of the falls, so dense that one cannot approach within 200 or 300 feet, and even then the clothes will be drenched in a few moments. Upon the yellow, nearly vertical wall of the west side, the mist mostly falls, and for 300 feet from the bottom the wall is covered with a thick matting of mosses, sedges, grasses, and other vegetation of the most vivid green, which have sent their small roots into the softened rocks, and are nourished by the ever-ascending spray. At the base and quite high up on the sides of the cañon, are great quantities of talus, and through the fragments of rocks and decomposed spring deposits may be seen the horizontal strata of breccia. (Fig. 24.)

Before proceeding further, I might attempt to give what appears to me to be the origin of this wonderful natural scenery. This entire basin was once the bed of a great lake, of which the lofty range of mountains now surrounding it formed the rim, and the present lake is only a remnant. During the period of the greatest volcanic activity this lake was in existence, though its limits, perhaps, could not now be easily defined; but it was at a later period inclosed within the rim. The basis rock is a very hard, compact basalt, not easily worn away by the elements. The surface is exceedingly irregular, and filling up these irregularities is a greater or less thickness of volcanic breccia and the deposits of hot springs. Upon all this, in some localities, continuing up to the time of the drainage of this lake, were deposited the modern volcanic clays, sands,

sandstones, and pudding-stones, which reach an aggregate thickness of 800 to 1,000 feet. Above the Upper Falls the Yellowstone flows over a hard, basaltic bed for sixteen miles from its outlet at the lake; there is then an abrupt transition from the hard basalt to the more yielding breccia, so that the river easily carved out a channel through it; the vertical walls are clearly seen from below the falls, passing diagonally across the rim. The Lower Falls are formed in the same way; the entire mass of the water falls into a circular basin, which has been worn into

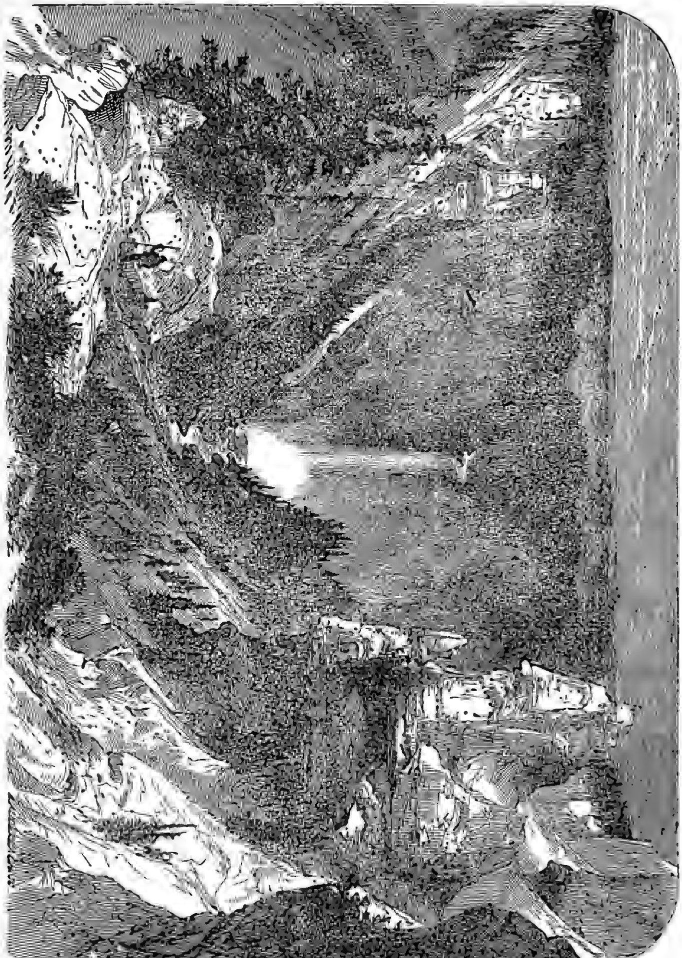


Fig. 24.

THE GREAT CAÑON AND LOWER FALLS OF THE YELLOWSTONE.

the hard rock, so that the rebound is one of the magnificent features of the scene. Below the Lower Falls the sides of the cañon show the material of which it is mostly composed. Where the river has cut its channel through the hard basalt, the irregular fissures, which undoubtedly extend down, in some manner, toward the heated interior, are distinctly seen. Local deposits of silica, as white as snow, sometimes 400 or 500 feet in thickness, are seen on both sides of the Yellowstone. These also are worn into columns, which stand out boldly from the nearly vertical sides in a multiplicity of picturesque forms. The basis material

of the old hot-spring deposits is silica, originally as white as snow, but very much of it is tinged with every possible shade of color, from the most brilliant scarlet to pink or rose color, from bright sulphur to the most delicate cream. There are portions of the day when these colors seem to be more vivid, and the rugged walls of the cañon stand out more in perspective, so that while the falls fill one with delight and admiration, the Grand Cañon surpasses all the others as the one unique wonder, without a parallel, probably, on our continent. We may conclude, therefore, from the point of view presented above, that while the cañon has somewhat the appearance of a great cleft or cañon, it is simply a channel carved by the river out of predeposited materials, after the drainage of the old lake-basin. The walls themselves, it seems to me, explain the manner in which the connection was formed from the surface with the heated interior, for they are seamed with the irregular fissures or furrows which pass up through the basalt and connect with the old hot-spring deposits. And so it is with the walls of the cañon, all the way to the mouth of Tower Creek; sometimes we find the irregular mason-work of the basalt, then the breccia or the curiously variegated hot-spring formations, the whole covered to a greater or less extent with a later deposit from the waters of the old lake, which now appears in horizontal strata.

As I have previously stated, the entire Yellowstone Basin is covered more or less with dead and dying springs, but there are centers or groups where the activity is greatest at the present time. Below the falls there is an extensive area covered with the deposits which extend from the south side of Mount Washburn across the Yellowstone rim, covering an area of ten or fifteen square miles. On the south side of Mount Washburn, there is quite a remarkable group of active springs. They are evidently diminishing in power, but the rims all around reveal the most powerful manifestations far back in the past. Sulphur, copper, alum, and soda cover the surface. There is also precipitated around the borders of some of the mud springs a white effloresence, probably nitrate of potash. These springs are located on the side of the mountain nearly 1,000 feet above the margin of the cañon, but extend along into the level portions below. In the immediate channel of the river, at the present time, there are very few springs, and these not important. A few small steam vents can be observed only from the issue of small quantities of steam. One of these springs was bubbling quite briskly, but had a temperature of only 100°. Near it is a turbid spring of 170°. In the valley are a large number of turbid, mud, and boiling springs, with temperatures from 175° to 185°. There are a number of springs that issue from the side of the mountain, and the waters, gathering into one channel, flow into the Yellowstone. The number of frying or simmering springs is great. The ground in many places, for several yards in every direction, is perforated like a sieve, and the water bubbles by with a simmering noise. There is one huge boiling spring which is turbid, with fine black mud all around the sides, where this fine black earth is deposited. The depth of the crater of this spring, its dark, gloomy appearance, and the tremendous force which it manifested in its operations, led us to name it the "Devil's Caldron." There are a large number of springs here, but no true geysers. It is plainly the last stages of what was once a most remarkable group. Extending across the cañon on the opposite side of the Yellowstone, interrupted here and there, this group of springs extends for several miles, forming one of the largest deposits of silica, but only here and there are there signs of life. Many of the dead springs are mere

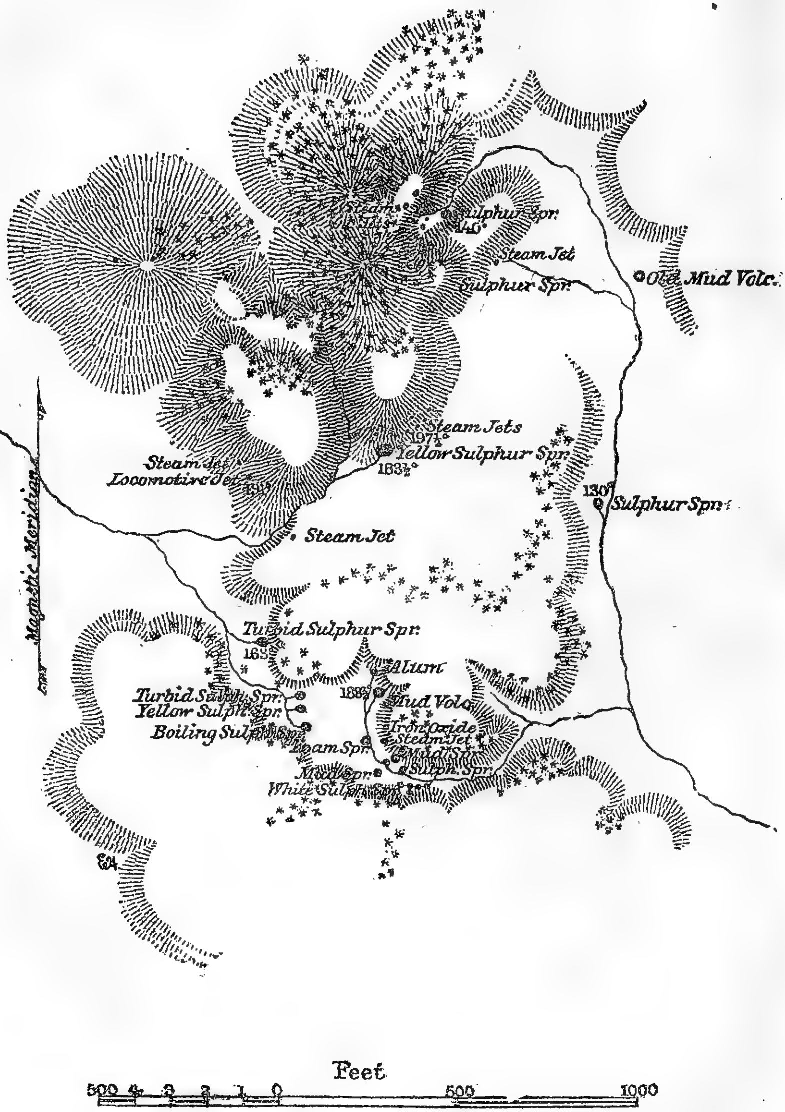
basins, with a thick deposit of iron on the sides, lining the channel of the water that flows from them. These vary in temperature from 98° to 120°. The highest temperature was 192°. The steam-vents are very numerous, and the chimneys are lined with sulphur. Where the crust can be removed, we find the under side lined with the most delicate crystals of sulphur, which disappear like frost-work at the touch. Still there is a considerable amount of solid amorphous sulphur. The sulphur and the iron, with the vegetable matter, which is always very abundant about the springs, give, through the almost infinite variety of shades, a most pleasing and striking picture. One of the mud springs, with a basin 20 by 25 feet and 6 feet deep, is covered with large bubbles or puffs constantly bursting with a thud. There are a number of high hills in this vicinity entirely composed of the hot-spring deposits, at least nine-tenths silica, appearing snowy-white in the distance; one of the walls is 175 feet high, and another about 70 feet. They are now covered to a greater or less extent with pines. Steam is constantly issuing from vents around the base and from the sides of these hills. There is one lake 100 by 300 yards, with a number of bubbling and boiling springs arising to the surface. Near the shore is one of the sieve-springs, with a great number of small perforations, from which the water bubbles up with a simmering noise; temperature, 188°. This group really forms one of the great ruins.

We will now return to the falls, and pursue our way up the valley of the Yellowstone to the lake. We wound our way among the dense pines that clothe the foot-hills, and, striking a game-trail, succeeded in avoiding the marshy bottoms of the river. Great numbers of small springs seem to flow out of the sides of the hills, and distribute themselves over the bottom, finally draining into the river. The deep snows which fall on the mountains, and continue the greater portion of the year, melt so gradually that these springs have a constant supply, and during the summer the grass and flowers give to the lowlands a meadow-like appearance by the freshness and vividness of the colors. The river, by its width, its beautiful curves, and easy flow, moves on down toward its wonderful precipices with a majestic motion that would charm the eye of an artist. Some of the little streams which we crossed on our way up the river were full of fresh-water shells. Wherever the water stands for a time, the surface is covered with a yellow scum from the presence of iron. About five miles above the falls, on the east side of the river, we crossed a small stream which held a large amount of alum in solution, and on this account was appropriately named Alum Creek. This little stream is 2 feet wide and 2 inches deep, as clear as crystal, and, as it flows along through the rich grass, it would not be noticed by the traveler that it differed from any other stream, except by the taste. Ever since descend ing into the basin we have met with great quantities of a kind of obsidian. It seldom occurs in a compact, amorphous, crystalline mass, like opaque glass, but as an aggregate of small amorphous masses, easily disintegrating, so that the surface is covered with the small obsidian pebbles. The color is black or dull purplish-black. There are exposures here and there of the basalt also; some of it contains great quantities of rounded masses, like concretions, from the size of a pea to 10 inches in diameter; they seem to be little geodes, found in the igneous mass, lined inside with crystals of quartz. These masses are sometimes called "volcanic walnuts" by travelers.

About ten miles above the falls, on the east side of the Yellowstone, we came to a most interesting group of hot springs, named, in Lieutenant Doane's report, the "Seven Hills." The chart which accompanies this report will show the location of the hills and the

springs in relation to them. (Fig. 25.) The little stream on the east side is one of the sources of Alum Creek, and the springs that border show the origin of the alum that is held in solution in the waters, which hold their full strength until they flow into the Yellowstone. We approached this

Fig. 25.



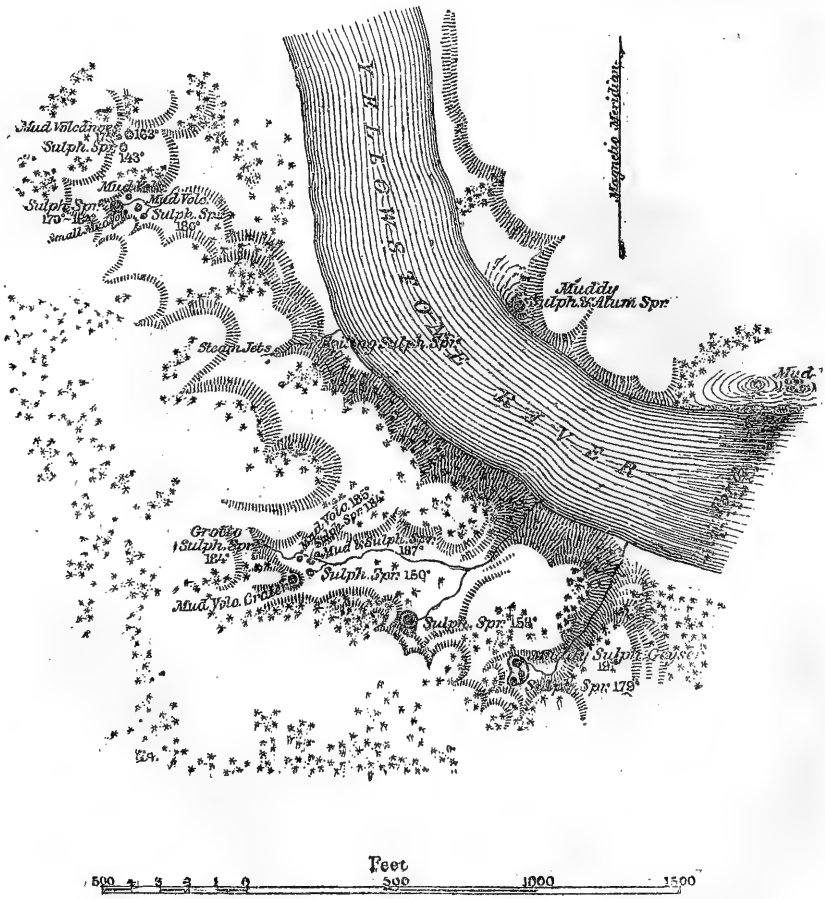
SULPHUR AND MUD SPRINGS, CRATER HILLS, YELLOWSTONE RIVER, 8 MILES BELOW THE LAKE.

group of springs on the west side, and the first spring that attracted our attention was located at the base of one of the white hills. It was a powerful steam-vent, with the strong, impulsive noise like a high-pressure

engine, and hence its name of Locomotive Jet. The aperture is about 6 inches in diameter, a sort of raised chimney, and all around it were numerous small continuous steam-vents, all of which were elegantly lined with the bright-yellow sulphur. The entire surface was covered with the white siliceous crust, which gives forth a hollow sound beneath the tread; and we took pleasure in breaking it up in the vicinity of the vents, and exposing the wonderful beauty of the sulphur-coating on the inner sides. This crust is ever hot, and yet so firm that we could walk over it anywhere. On the south side of these hills, close to the foot, is a magnificent sulphur-spring. The deposits around it are silica; but some places are white, and enameled like the finest porcelain. The thin edges of the nearly circular rim extend over the waters of the basin several feet, yet the open portion is 15 feet in diameter. The water is in a constant state of agitation. The steam that issues from this spring is so strong and hot that it was only on the windward side that I could approach it and ascertain its temperature, 197°. The agitation seemed to affect the entire mass, carrying it up impulsively to the height of 4 feet. It may be compared to a huge caldron of perfectly clear water somewhat superheated. But it is the decorations about this spring that lent the charm, after our astonishment at the seething mass before us—the most beautiful scolloping around the rim, and the inner and outer surface covered with a sort of pearl-like bead work. The base is the pure white silica, while the sulphur gave every possible shade, from yellow to the most delicate cream. No kind of embroidering that human art can conceive or fashion could equal this specimen of the cunning skill of nature. On the northeast side of the hills, extending from their summits, are large numbers of the steam-vents, with the sulphur linings and deposits of the sulphur over the surface. These hills are entirely due to the old hot springs, and are from 50 to 150 feet in height. The rock is mostly compact silica, but there is almost every degree of purity, from a kind of basalt to the snow-white silica. Some of it is a real conglomerate, with a fine siliceous cement inclosing pebbles of white silica, like those seen around the craters of some geysers. Although at the present time there are no true geysers in this group, the evidence is clear that these were, in former times, very powerful ones, that have built up mountains of silica by their overflow. The steam-vents on the side and at the foot of these hills represent the dying stages of this once most active group. Quite a dense growth of pines now covers these hills. They rise up in the midst of the plains, and from their peculiar white appearance are conspicuous for a great distance. At one point there is a steam-vent so hot that it is difficult to approach it, emitting a strong sulphurous smell, and within two feet of it there is a larger spring, boiling like a caldron. So far as I can determine, there is no underground connection of any of the springs with each other. Sometimes the rims of these craters, as well as the inner sides of their basins, have a beautiful papulose surface, the silica just covered with a thin veil of delicate creamy sulphur. At this locality are some very remarkable turbid and mud springs, on the south portion of this singular group, as can be seen by reference to the chart. One of them has a basin 20 feet in diameter, nearly circular in form, and the contents have almost the consistency of thick hasty-pudding. The surface is covered all over with puffs of mud, which, as they burst, give off a thud-like noise, and then the fine mud recedes from the center of the puffs in the most perfect rings to the side. This mud-pot presents this beautiful picture; and although there are hundreds of them, yet it is very rare that the mud is just in the condition to admit of these peculiar rings. The kind

of thud is, of course, produced by the escape of the sulphureted hydrogen gas through the mud. Indeed, there is no comparison that can bring before the mind a clearer picture of such a mud volcano than a huge caldron of thick mush. The mud is so fine as to have no visible or sensible grain, and is very strongly impregnated with alum. For three hundred yards in length and twenty-five yards in width, the valley of this little branch of Alum Creek is perforated with these mud-vents of all sizes, and the contents are of all degrees of consistency, from merely turbid water to a thick mortar. The entire surface is perfectly bare of vegetation and hot, yielding in many places to a slight pressure. I attempted to walk about among these simmering vents, and broke through to my knees, covering myself with the hot mud, to my great pain and subsequent inconvenience. One of the largest of the turbid springs has a basin with a nearly circular rim 20 feet from the margin to the water, and 40 feet in diameter. There are two or three cen-

Fig. 26.



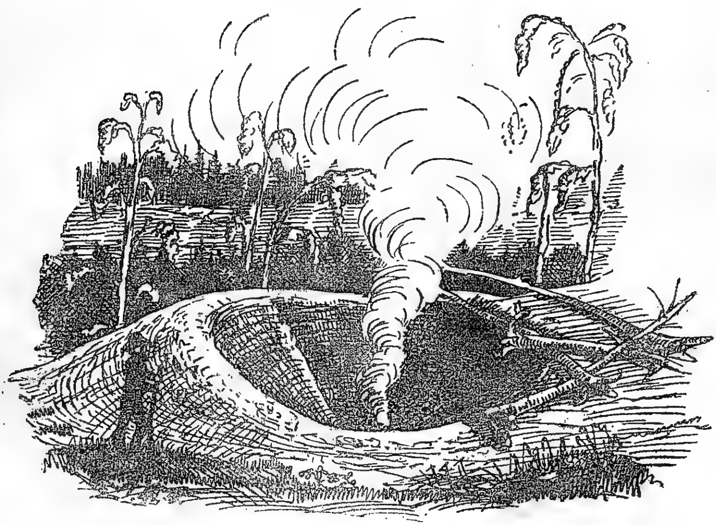
SULPHUR AND MUD SPRINGS, YELLOWSTONE RIVER, 6 MILES BELOW THE LAKE.

ters of ebullition; temperature, 188°. We may say, in conclusion, in regard to this group, that while there is a great deal of activity in the

springs at the present time, the remains of the dead springs cover the greater portion of the surface, and those which are more active present the evidence of far greater power in past times.

From this point we proceeded to the sulphur and mud springs near the banks of the Yellowstone, about two miles above, in a straight line. In the interval we passed the remains of many old springs, but none above the ordinary temperature; but the deposit seemed to cover the surface more or less. The old lake deposit is also quite well shown in the rather high, step-like hills which extend back for five miles from the river to the basaltic rim of the great basin. We pitched our camp on the shore of the river, near the Mud Springs, thirteen and a half miles above our camp, on Cascade Creek. The springs are scattered along on both sides of the river, sometimes extending upon the hill-sides 50 to 200 feet above the level of the river. The chart will show the location of the principal ones. (Fig. 26.) Commencing with the lower or southern side of the group, I will attempt to describe a few of them. The

Fig. 27.



MUD CALDRON, YELLOWSTONE RIVER.

first one is a remarkable mud-spring, with a well-defined circular rim, composed of fine clay, and raised about 4 feet above the surface around, and about 6 feet above the mud in the basin. The diameter of the basin is about 8 feet. The mud is so fine as to be impalpable, and the whole may be most aptly compared to a caldron of boiling mush. The gas is constantly escaping, throwing up the mud from a few inches to 6 feet in height; and there is no doubt that there are times when it is hurled out 10 to 20 feet, accumulating around the rim of the basin. (Fig. 27.) About twenty yards distant from the mud-spring just described, is a second one, with a basin nearly circular, 40 feet in diameter, the water 6 or 8 feet below the margin of the rim. The water is quite turbid, and is boiling moderately. Small springs are flowing into it from the south side, so that the basin forms a sort of reservoir. The temperature, in some portions of the basin, is thus lowered to 98°. Several small hot springs pour their surplus water into it, the temperatures of which are 180°, 170°, 184°, and 155°. In the reservoirs, where the water boils up

with considerable force, the temperature is only 96°, showing that the bubbling was due to the escape of gas. The bubbles stand all over the surface. About 20 feet from the last, is a small mud-spring, with an orifice 10 inches in diameter, with whitish-brown mud, 182°. Another basin near the last has two orifices, the one throwing out the mud with a dull thud about once in three seconds, spurting the mud out 3 or 4 feet; the other is content to boil up quite violently, occasionally throwing the mud 10 to 12 inches. This mud, which has been wrought in these caldrons for perhaps hundreds of years, is so fine and pure that the manufacturer of porcelain-ware would go into ecstacy at the sight. The contents of many of the springs are of such a snowy whiteness that, when dried in cakes in the sun or by a fire, they resemble the finest meerschaum. The color of the mud depends upon the superficial deposits which cover the ground, through which the waters of the springs reach the surface. They were all clear hot springs originally, perhaps geysers even; but the continual caving in of the sides has produced a sort of mud-pot, exactly the same as the process of preparing a kettle of mush. The water is at first clear and hot; then it becomes turbid from the mingling of the loose earth around the sides of the orifice, until, by continued accessions of earth, the contents of the basin become of the consistency of thick mush, and, as the gas bursts up through it, the dull, thud-like noise is produced. Every possible variation of condition of the contents is found, from simple milky turbidness to a stiff mortar. On the east side of the Yellowstone, close to the margin of the river, are a few turbid and mud springs, strongly impregnated with alum. The mud is quite yellow, and contains much sulphur. This we called a mud-sulphur spring. The basin is 15 by 30 feet, and has three centers of ebullition, showing that deep down underneath the superficial earth, there are three separate orifices, not connected with each other, for the emission of the heated waters. Just opposite this spring, on the west side of the river, is a singular vertical wall of rather coarse basalt, which looks like huge mason-work, separated by the jointage into nearly rectangular blocks. The wall is about 50 feet high, and is important in giving us an exposure of the basis rock of this region. The surface is mostly covered with a thick deposit of clay of modern origin; but the heated waters must pass a great distance through these igneous rocks, dissolving from them great quantities of silica and other chemical materials which we find so abundantly around the springs. The next interesting spring we called the Grotto. (Fig. 28.) A vast column of steam issues from a cavern in the side of the hill, with an opening about 5 feet in diameter. The roaring of the waters in the cavern, and the noise of the waves as they surge up to the mouth of the opening, are like that of the billows lashing the sea-shore. The water is as clear as crystal, and the steam is so hot that it is only when a breeze wafts it aside for a moment one can venture to take a look into the opening. From the tremendous roaring and dashing of the waters against the sides of the cavern, one would suppose that the amount must be great, but not

Fig. 28.

GROTTO, YELLOWSTONE RIVER.

more than ten gallons an hour pass out of it in the little channel that leads from it. On either side of the cavern, where the steam strikes, there is a thin coating of vegetation of a deep, vivid green. In the vicinity of these springs, various kinds of grasses, rushes, mosses, and other plants grow with a surprising luxuriance. Over the "grotto" there is a thickness of about 30 feet of stratified clay, with a fine texture. Located higher up on the side of the hill, not far from the grotto, is the most remarkable mud-spring we have ever seen in the West. The rim of the basin is formed by the loose mud or clay thown out of the orifice. It is about 40 feet in diameter at the top, but tapering down to half the size, and is about 30 feet deep. It may not improperly be called the Giant's Caldron. (Fig. 29.) It does not boil with an impulse like most of the mud-springs, but with a constant roar which shakes the ground for a considerable distance, and may be heard for half a mile. A dense column of steam is ever rising, filling the crater, but now and then a passing breeze will remove it for a moment, revealing one of the most terrific sights one could well imagine. The contents are composed of thin mud in a continual state of the most violent agitation, like an immense caldron of mush submitted to a constant, uniform, but most intense heat. That it must have had its spasms of ejection is plain from the mud on the trees for a radius of a hundred feet or more in every direction from the crater, and it would seem that the mud might have been thrown up to the height of 75 or 100 feet. This ejection of the mud must have occurred within a year or two, from the fact that small pines near the crater are still green, though covered with mud. Small pines 4 inches in diameter and 20 to 30 feet in height have been permitted to grow within 10 and 20 feet of the rim, and, therefore, the throwing of the mud to any distance from the crater must occur very seldom. A few of the trees near the crater, which were covered with the mud, were killed by the heat, but others that are literally festooned with it, have only the small branches and leaves destroyed. All the indications around this most remarkable caldron show that it has broken out at a recent period; that the caving in of the sides so choked up the orifice that it relieved itself, hurling the muddy contents over the living pines in the vicinity. The steam which arises from this caldron may be seen for many miles in every direction. There are a large number of springs all around, some boiling and others quiet, some of which are of great size and quite worthy of attention, but we will describe only one more in this group. At the south side there is a large basin, 200 by 300 feet, containing within the rim three boiling springs. The two smaller ones on the south side of the rim are separated from each other by a partition of about 4 feet, and are mud-springs, and boil up in the centers at this time 6 or 8 inches. Their basins are 10 and 20 feet in diameter. The third basin is the largest, with a rim 30 by 50 feet, and is a true geyser; when not in operation, the fine mud settles to the bottom and the water becomes clear. This is constantly but moderately agitated, not sufficiently to stir up the

Fig. 29.

GIANT'S CALDRON, YELLOWSTONE RIVER.

mud at the bottom. A channel has been formed 8 feet deep through the fine clay, which carries the surplus water from the crater to the river.

MUD GEYSER.

Fig. 30.

This is a true intermittent spring. July 28 and 29 it played several times, throwing the water to the height of 20 to 30 feet. (Fig. 30.) The

impression among the mountain-men was, that this is a periodic spring, and played once in six hours precisely. In order to test this belief, I directed my assistant, Mr. Campbell Carrington, with one non-commissioned officer of the escort, to return from our camp on the lake, and note minuteley the movements of this spring for twenty-four hours in succession. The following interesting report was made by Mr. Carrington:

"We arrived at the mud-geysers ten minutes after 9 o'clock a. m., July 1. The pool was calm, with the exception of the little boiling bubbles that are always on its surface. In circumference it measures nearly 100 feet. While selecting a place to camp, unsaddling our horses, &c., we heard a loud, hissing noise, as an escape of steam. Hurrying to the geyser, I saw a wave about three feet in height rise and die away to the left; three similar ones followed in quick succession. It then, with a dull, heavy sound, accompanied by dense columns of steam, suddenly burst up to the height of 20 feet. It continued in action for the space of fifteen minutes, when it ceased flowing as suddenly as it had commenced. The average height of this flowing was about 15 feet, although some jets reached fully 30. Five minutes after the eruption, the pool measured 25 feet in circumference and 3 in depth, where before it was 100 feet in circumference and 11 in depth. Ten minutes after (at 9.45 a. m.) I noticed that it was slowly commencing to rise again. It continued to do so until twenty minutes after one, (1.20 p. m.,) when it began to boil near the center, a black formation making a ring around the boiling part. This boiling gradually increased in violence, lasting twenty minutes; it then suddenly stopped, and a wave 2 or 3 feet in height arose, dying away to the left, and the flowing then took place as before described. Average height of this flowing, 15 feet; duration, 20 minutes.

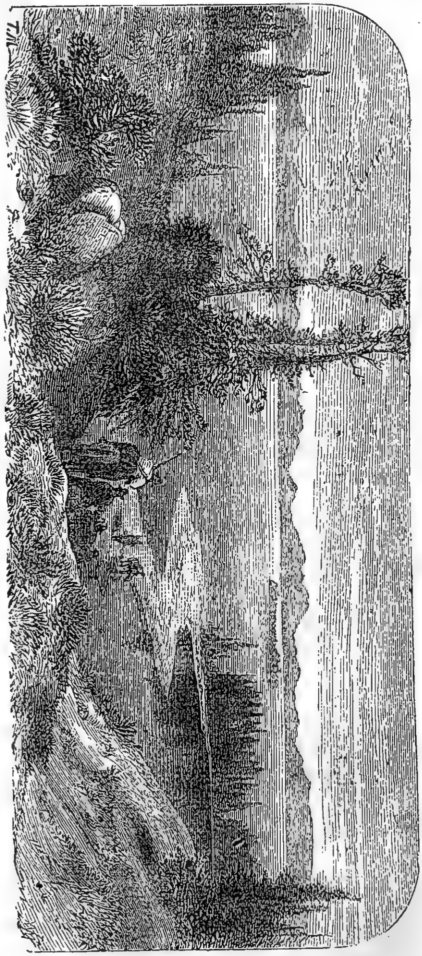


Fig. 31.

YELLOWSTONE LAKE.

"This rising, falling, and overflowing took place eight times in twenty-four hours, the circumstances connected with each one being almost exactly the same. Appended below is a table of the time and length of flowings:

" *Time of flowings.*

"Arrived at 9.10 a. m.

" First flowing, 9.20 a. m. to 9.35 a. m.; length, 15 minutes.

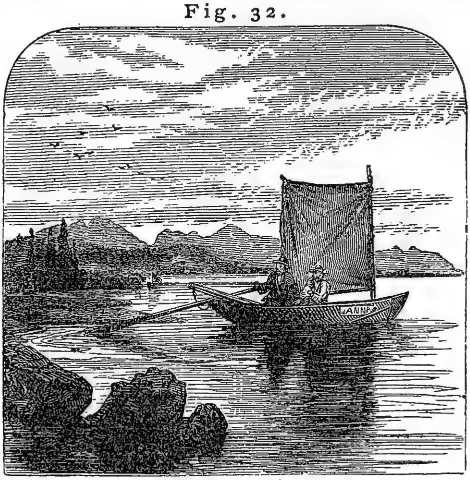
"Second flowing, 1.30 p. m. to 1.50 p. m.; length, 20 minutes.
"Third flowing, 5 p. m. to 5.15 p. m.; length, 15 minutes.
"Fourth flowing, 8.30 p. m. to 8.50 p. m.; length, 20 minutes.
"Fifth flowing, 12.30 p. m. to 12.45 p. m.; length, 15 minutes.
"Sixth flowing, 4 a. m. to 4.15 a. m.; length, 15 minutes.
"Seventh flowing, 7.30 a. m. to 7.45 a. m.; length, 15 minutes.
"Eighth flowing, 11 a. m. to 11.10 a. m.; length, 10 minutes.

"Total length of time, 26 hours. Aggregate time of flowings, 3 hours and 15 minutes. Average length of flowings, 15 minutes and 37½ seconds."

On the 28th of July we arrived at the lake, and pitched our camp on the northwest shore, in a beautiful grassy meadow or opening among the dense pines. The lake lay before us, a vast sheet of quiet water, of a most delicate ultramarine hue, one of the most beautiful scenes I have ever beheld. (Fig. 31.) The entire party were filled with enthusiasm. The great object of all our labors had been reached, and we were amply paid for all our toils. Such a vision is worth a lifetime, and only one of such marvelous beauty will ever greet human eyes. From whatever point of view one may behold it, it presents a unique picture. We had brought up the frame-work of a boat 12 feet long and 3½ feet wide, which we covered with stout ducking, well tarred. On the morning of the 29th, Messrs. Stevenson and Elliott started across the lake in the Anna, the first boat ever launched on the Yellowstone, and explored the nearest island, which we named after the principal assistant of the expedition, who was undoubtedly the first white man that ever placed foot upon it.

Our little bark, which is well shown in figure 32, whose keel was the first to plow the waters of the most beautiful lake on our continent, and which must now become historical, was named by Mr. Stevenson in compliment to Miss Anna L. Dawes, the amiable daughter of Hon. H. L. Dawes. My whole party were glad to manifest, by this slight tribute, their gratitude to the distinguished statesman, whose generous sympathy and aid had contributed so much toward securing the appropriation which enabled them to explore this marvelous region.

Fig. 32.



THE "ANNA."

Usually in the morning the surface of the lake is calm, but toward noon and after, the waves commence to roll, and the white caps rise high, sometimes four or five feet. Our little boat rode the waves well; but when a strong breeze blew, the swell was too great, and we could only venture along the shore. This lake is about twenty-two miles in length from north to south, and an average of ten to fifteen miles in width from east to west. It has been aptly compared to the human hand; the northern portion would constitute the palm, while the southern prolongations or arms might represent the fingers. The map itself, which shows all the soundings, will best convey to the eye of the reader its peculiar form. There are some of the most beautiful shore-lines along this lake that I

ever saw. Some of the curves are as perfect as if drawn by the hand of art. Our little boat performed most excellent service. A suitable frame-work was fastened in the stern for the lead and line, and with the boat, a system of soundings was made that gave a very fair idea of the average depth of the lake. The greatest depth discovered was 300 feet. It is fed by the snows that fall upon the lofty ranges of mountains that surround it on every side. The water of the lake has at all seasons nearly the temperature of cold spring-water. The most accomplished swimmer could live but a short time in it; the dangers attending the navigation of such a lake in a small boat, are thereby greatly increased. The amount of vegetable matter in the lake is enormous. At certain seasons of the year, the waves throw upon the shore a windrow of drifted vegetation. Frequently, after a strong wind, the water of the entire border of the lake for several yards from the shore will be filled with minute fragments of vegetation broken by the waves, rendering the water quite impure. Several species of plants grow far out into the deep waters, and I have seen them growing thickly on the rocks at the bottom 10 to 20 feet in depth. We were able to discover but one species of fish in the lake, and that was trout, weighing from two to four pounds each. Most of them are infested with a peculiar intestinal worm, which has been described by Dr. Leidy, in a subsequent portion of this report, as a new species, under the name of *Dibothrium cordiceps*. I directed Mr. Campbell Carrington, naturalist to the expedition, to prepare the following notes on this subject:

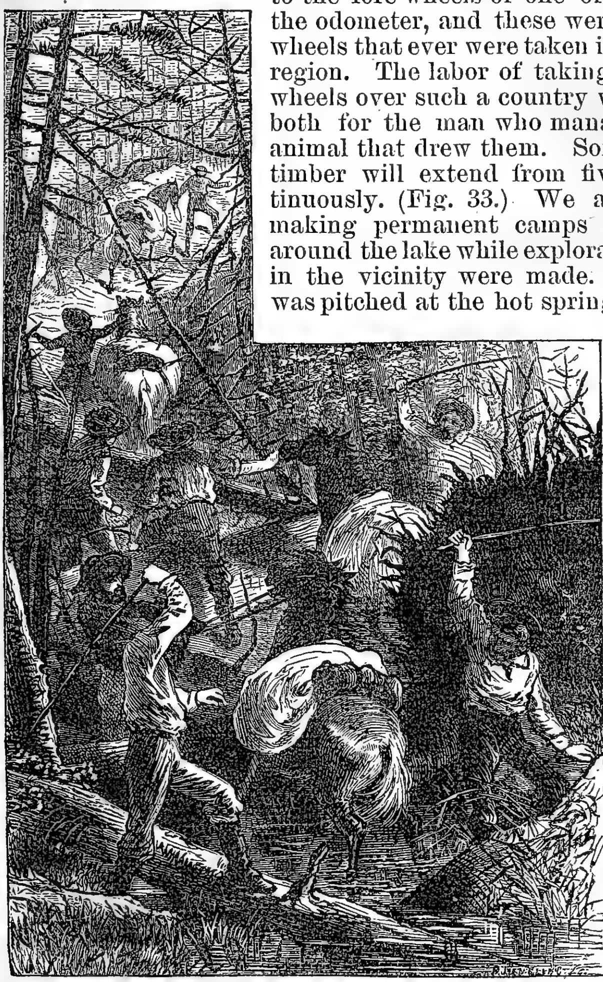
THE TROUT OF YELLOWSTONE LAKE.—"Although I searched with diligence and care in the neighboring streams and waters around the Yellowstone Lake, I was unable to find any other species of fish except the salmon-trout; their numbers are almost inconceivable; average weight, one pound and a half; color, a light-gray above, passing into a light-yellow below; the fins, all except the dorsal and caudal, vary from a bright-yellow to a brilliant orange, they being a dark-gray and heavily spotted. A curious fact, and one well worthy of the closest attention of an aspiring icthyologist, is connected with these fish, namely, that among their intestines, and even interlaced in their solid flesh, are found intestinal worms, varying in size, length, and thickness, the largest measuring about six inches in length. On cutting one of these trout open, the first thing that attracts your attention, are small oleaginous-looking spots clinging to the intestines, which, on being pressed between the fingers, break and change into one of these worms, small, it is true, but nevertheless perfect in its formation. From five or six up to forty or fifty will be found in a trout, varying, as I said before, in size, the larger ones being found in the solid flesh, through which they work their way, and which, in a very short while, becomes almost putrid. Their number can generally be estimated from the appearance of the fish itself; if many, the trout is extremely poor in flesh, the color changes from the healthy gray to a dull pale, it swims lazily near the top of the water, losing all its shyness and fear of man; it becomes almost savage in its appetite, biting voraciously at anything thrown in the water, and its flesh becomes soft and yielding. If, on the other hand, there are few or none, the flesh of the fish is plump and solid, and he is quick and sprightly in all his motions. I noticed that it was almost invariably the case when a trout had several scars on the outside of his body that it was free from these worms, and I therefore took it for granted that the worms finally worked their way through the body, and the flesh, on healing up, leaves the scars on the outside; the trout, in a short while, becomes plump and healthy again. The only

way that I can account for the appearance of these worms is, that the fish swallows certain bugs or insects, and that the larvæ formed from them gradually develop into the full-grown intestinal worm. But even if this explanation of their appearance was received, does it not seem a little strange that while all the fish above the Upper Falls are more or less affected by them, that below and even between the Upper and Lower Falls such a thing as wormy trout is never heard of. Being unable, with my limited knowledge of ichthyology, to arrive at any definite conclusion in regard to their appearance, I submit the above facts to those who are more learned than myself in this most interesting branch of natural history."

I will not, in this place, present a detailed description of this wonderful lake, but simply notice it in general terms. As we proceed from point to point around its borders, its most prominent features will be described. We regard the lake-basin as due in part to erosion. All along its margin are high banks and terraces, composed of a modern stratified deposit, passing up into an aggregation of sand, pebbles, &c., which is not unfrequently cemented into a tolerably firm conglomerate. These deposits, which are made up of eroded volcanic rocks, have in some instances the white appearance and somewhat the composition of Pliocene clays, marls, and sands of the other lake-basins along the Missouri and the Lower Yellowstone. In the northern portion of the basin, these deposits reach a thickness of 300 to 600 feet, and must be of the later Pliocene era and even extending down to the present time. The two lakes were then connected, although probably never completely united. The belt of mountains that separated them was about four miles in width. I have estimated that, since the period of volcanic activity, the depth of the lake has been about 500 feet greater than at present, the shore-lines being then high upon the side of the surrounding mountains. During the time of the greatest volcanic action, the waters must have covered the loftiest peaks; for many of them are composed of the breccia or conglomerate in a regularly stratified condition. This breccia surrounds the highest volcanic cones or nuclei, as Mounts Doane, Stevenson, &c. The area occupied by the lake is now gradually but very slowly diminishing. Our course around the lake was along the west side, from the outlet of the Yellowstone. Our purpose was to make a careful topographical and geological survey of the shore-line, to note every bay or indentation, and every little stream that poured its waters from the surrounding mountains. Messrs. Elliott and Carrington made a careful topographical and pictorial chart of the shore-lines as well as the islands from our boat, so that it is hardly possible for the work to have been made more complete. The immediate lake shores are paved with the volcanic rocks which form the rim that surrounds it. Fragments of obsidian prevail, but there are great quantities of the breccia and trachyte also. The immediate rim of the basin on the west side is marked by a peculiar series of step-like ridges, which are not continuous for long distances, but appear to be the result of slides. The surface waters from the snows have doubtless gradually undermined vast portions of the mountain sides, and they have fallen down at different levels, leaving between the detached mass and the parent mountain a depressed interval of greater or less width, in which there is a meadow-marsh or small lake. These steps or terraces are covered with a dense growth of pines; and even on the sides of the mountains, which are so steep that it was impossible to ascend them with our animals, small groups of pines cling to the thin soil. On account of the almost vertical sides of this

mountain, and the rounded form of the summit, it has received the name of the Elephant's Back. Obsidian, volcanic breccia, and trachyte constitute the varieties of rocks for the most part. The general elevation is about 10,000 feet. There are no streams of any size flowing into the lake on the west side, and therefore there are no depressions of any importance in the rim that would form passes over the divide. It is around the lake and among the mountains that border it that we encounter the most formidable impediments to traveling. The autumnal fires sweep among the dense pine forests, and the winds then lay them down in every possible direction. Sometimes a perfect net-work, 6 feet in height, is formed of these tall pines, which are 100 to 150 feet in length, and it was with the utmost difficulty that we could thread our tortuous way among them. We attached a pair of shafts to the fore-wheels of one of our ambulances for the odometer, and these were probably the first wheels that ever were taken into this little-known region. The labor of taking this single pair of wheels over such a country was extremely great, both for the man who managed them and the animal that drew them. Sometimes this fallen timber will extend from five to ten miles continuously. (Fig. 33.) We adopted the plan of making permanent camps at different points around the lake while explorations of the country in the vicinity were made. Our second camp was pitched at the hot springs on the southwest arm. This position commanded one of the finest views of the lake and its surroundings. While the air was still, scarcely a ripple could be seen on the surface, and the varied hues, from the most vivid green shading to ultramarine, presented a picture that would have stirred the enthusiasm of the most fastidious artist. Sometimes in the latter portion of the day a strong wind would arise, arousing this calm surface into waves like the sea. Near our camp there is a thick deposit of the silica, which has been worn by the waves into a bluff wall 25 feet high above the water. It must have originally extended far out into the lake. The belt of springs at this place is about three miles

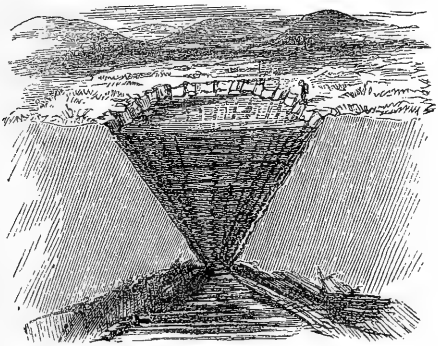
Fig. 33.



TRAVELING IN THE YELLOWSTONE COUNTRY.

long and half a mile wide. The deposit now can be seen far out in the deeper portions of the lake, and the bubbles that arise to the surface in various places indicate the presence at the orifice of a hot spring beneath. Some of the funnel-shaped craters extend out so far into the lake that the members of our party stood upon the silicious mound, extended the rod into the deeper waters, and caught the trout and cooked them in the boiling spring without removing them from the hook. These orifices, or chimneys, have no connection with the waters of the lake. The hot fumes coming up through fissures extending down toward the interior of the earth are confined within the walls of the orifice, which are mostly circular and beautifully lined with delicate porcelain. Figure 34 exhibits a fine cross-section of one of these funnel-shaped basins. Wherever the heated water issues from orifices at the bottom of the lake the temperature is changed. The deposit of silica along the shore has been built up in extremely thin layers, or laminæ, never more than the sixteenth of an inch in thickness. The shore, for several yards in width, is covered to a considerable thickness with the disintegrated silica, so that in walking over, it seems like treading on the broken fragments of washed shells along the sea-shore. Much of the *débris* has been cemented together, so that there are large masses scattered around, like the Florida coquina.

Fig. 34.



SECTION OF LARGE SPRING, YELLOWSTONE LAKE.

The question will arise as to the time that must have elapsed during the deposition of this thick bed of silica. We may take the position that no new groups of springs break out, or have done so in modern times. Isolated springs connected with groups may form new openings, however. We may, therefore, start from the period of the cessation of the volcanic forces of this region, and trace the history down to the present time. Very numerous groups have gone through with their period of activity, and now nothing but a mass of ruins is left. It is quite possible that this group manifested its greatest power when the lake extended all over the belt. The waters of the lake have undoubtedly receded from the area occupied by this belt of springs within a comparatively recent period. We may say that the deposition of the beds, so far as is shown by any evidence we can gather at this time, has probably occupied one or two thousand years.

Fig. 35.

MUD PUFF, YELLOWSTONE RIVER.

The springs of this group are very numerous, of great variety and interest, but there are no true geysers. Some of these are what I would call pulsating springs; that is, the water rises and falls in the orifice with great regularity once in two or three seconds. There are also a great number of mud-springs high up on the

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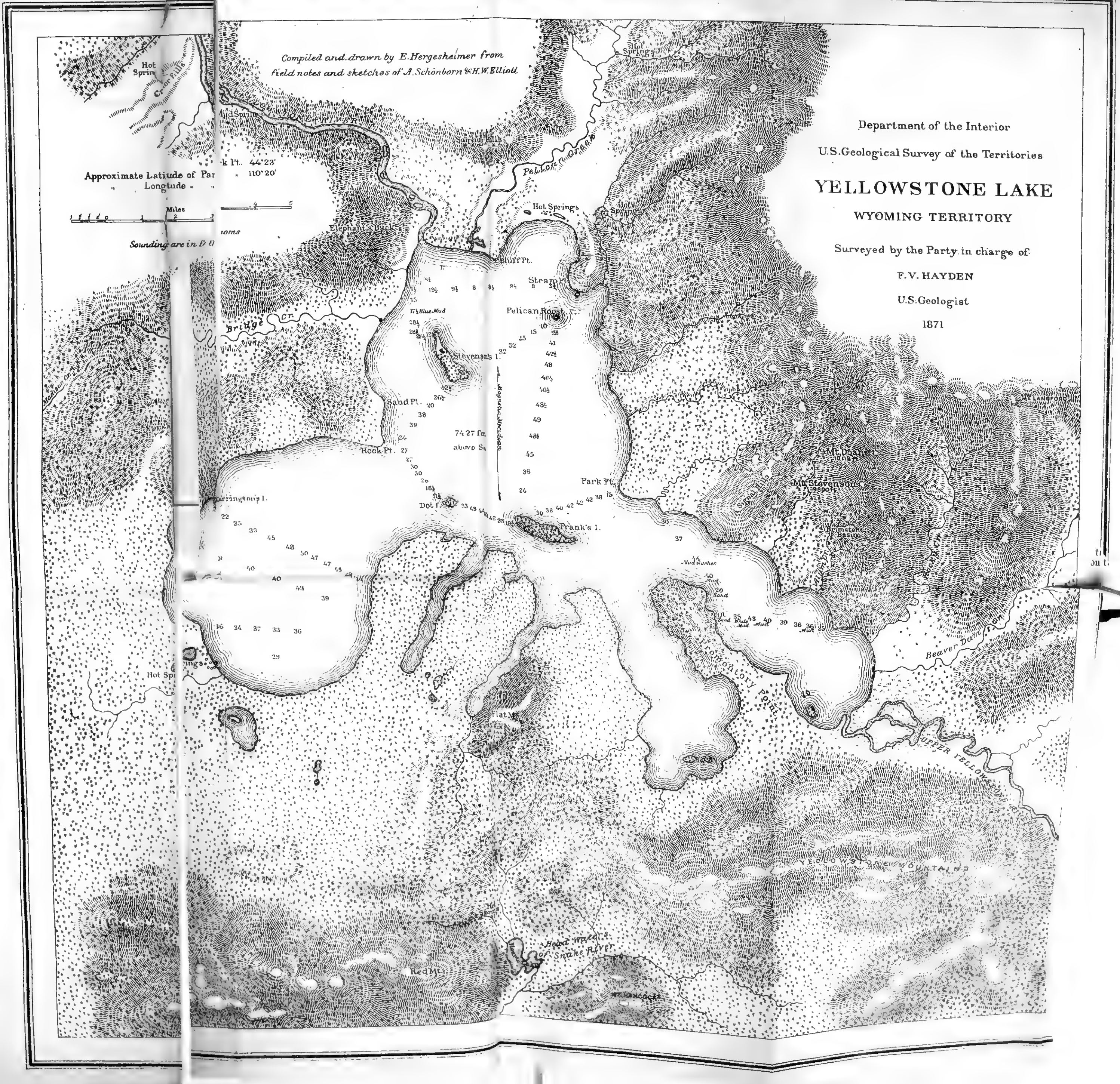

Department of the Interior
U.S. Geological Survey of the Territories
YELLOWSTONE LAKE
WYOMING TERRITORY
Surveyed by the Party in charge of
F. V. HAYDEN
U.S. Geologist
1871
Compiled and drawn by E. Hergesheimer from
field notes and sketches of A. Schönborn & H. W. Elliott
Approximate Latitude of Par k Pt. 44°23'
Longtude 110°20'
Miles
Soundings are in f ath oms
Hot Spring
Mud Spring
Sulphur Hills
Pelican Creek
Hot Springs
Elephant's Back
Bluff Pt.
Steam Pt.
Pelican Roost
Bridge Cr.
Stevenson's I.
Sand Pt.
Rock Pt.
7427 feet above Sea
Magnetic Meridian
Park Pt.
Dot I.
Frank's I.
Carrington's I.
Mud Rushes
Promontory Point
Mt. Langford
Mt. Doane
Mt. Stevenson
Brimstone Basin
Beaver Dam Cr.
Upper Yellowstone
Flat Mt.
Yellowstone Mountains
Head Waters of Snake River
Red Mt.
Mt. Hancock

bank, where the orifice comes up, a considerable distance, through the soft superficial clays. The constant thud may be heard at our camp night and day from half a dozen of these mud-puffs. (Fig. 35.) They have built up a large number of small circular mounds about 2 feet high. These springs do not differ essentially from the others which have been described. There are some two hundred or three hundred in all, of all sizes, and of variable temperatures. Some of them are 50 feet in diameter, and when sounded with a lead showed a depth of 40 to 50 feet. One of them was as clear as crystal, and the funnel-shaped basin was 45 feet in depth. So clear was the water that the smallest object could be seen on the sides of the basin, so that, as the breeze swept across the surface, the ultramarine hue of the transparent depth in the bright sunlight was the most dazzlingly beautiful sight I have ever beheld. There were a number of these large clear springs, but not more than two or three that exhibited all those brilliant shades, from deep-sea green to ultramarine, in the sunlight. The surface in some places is covered with a most singular substance, which seems to have been precipitated by the overflow of the springs; it is very prettily variegated, every shade of green, yellow, or pink and rose color, but not as vivid as in some other localities. The deposit is about two inches in thickness, and breaks easily; it seems to the touch like jelly; it is largely vegetable, without doubt composed of diatoms.

Underneath this silicious deposit, and along the shore of the lake on either side of this group of springs, are fine exposures of the strata of the modern lake deposit which I have so often alluded to. Sandstones, pudding-stones, and indurated clays, all formed of decomposed volcanic rocks, present fine exposures. They extend high up on the borders of the lake. Within half a mile of this camp there is a small lake, hidden among the dense forests, about a mile in length, and half a mile wide, and perhaps 30 or 40 feet higher than the main lake. It seems to occupy a depression, and, though entirely isolated at present, was once, no doubt, a portion of the great lake. I believe that the rivers and lakes, large and small, which are distributed among the dense forests around the lakes, are simply fragments, that have been cut off by the decrease of the area occupied by the old lake basin. There are a few hot springs near Heart Lake, one of which is a moderate-sized geyser, but the group is not one of much importance.

CHAPTER VI.

FROM YELLOWSTONE LAKE TO THE GEYSER BASINS OF FIRE-HOLE RIVER, AND RETURN.

On the morning of July 31, I detailed a small party from our camp on the northwest shore of the lake to make the examination of the far-famed geyser basin of the Fire-Hole River. Mr. Schonborn, topographer, Mr. Elliott, artist, and Dr. Peale, mineralogist, accompanied me. We took a southwesterly course, intending to strike some of the branches of the Madison, and follow them down until we came to the springs. Having no guide, we became involved in the net-work of fallen timber, which at times threatened to obstruct our passage altogether. We traveled thirty-one and one-half miles that day, and at least twelve of them were among the fallen pines, where we were obliged to wind our way wherever we could find the prostrate trees low enough for our

mules to pass over them. Now and then we would come out into an open glade, and start on at a brisk pace with fresh hope, when we would come again to a belt of this remarkable net-work of fallen pines. In all our journey we found but two kinds of rock, the black obsidian and the usual trachyte. At one point, soon after leaving camp, we found a most singular natural bridge of the trachyte, which gives passage to a small stream, which we called Bridge Creek. There is barely room across it for a trail about two feet wide, which is used only by herds of elk that are passing daily. The descent on either side is so great that a fall from it would be fatal to man or beast. Every few minutes we met with a group of dead or dying springs; very few of them contain water at the present time, but steam was issuing from hundreds of vents. There was one locality where the deposit covered several acres that presented a most attractive picture. The entire area was thickly covered with conical mounds of various sizes, ranging in diameter from a few inches to a hundred feet or more, and these cones, or hillocks, were full of orifices from which steam was issuing. All these little chimneys, or orifices, were lined with the most brilliant crystals of sulphur, and, when the heated crust was removed, we found the under side adorned in the same manner. The basis of the deposit was silica, as white as snow; but it was variegated with every shade of yellow from sulphur, and with scarlet or rose color from oxide of iron. In the distant view the appearance of the whole country may be not unaptly compared to a vast lime-kiln in full operation. Most of the country passed over has been washed into rounded hills from 50 to 200 feet in height, composed of the whitish, yellow, pinkish clays and sands of the modern lake deposits. This deposit seems to prevail, more or less, all around the rim of the basin, reaching several hundred feet above the present level of the lake. At another locality there was quite a large stream of hot water, formed by the overflow of a group of springs. One of the springs was constantly throwing up a column of water several feet. In this deposit there was a large amount of calcareous matter, which is quite unusual in the Yellowstone Basin. We know, however, that there are patches of the Carboniferous limestone here and there, remnants of the great series of strata that once covered the entire region. There is no doubt that if sufficient time was given to explore all the country about the sources of the Yellowstone, Missouri, and Snake Rivers, great numbers of other groups of springs of greater or less importance would be found, which, as yet, have never been seen by human eye. Fortunately for us, in our wanderings we struck the sources of the East Fork of the Madison instead of those of the Fire-Hole, and, in consequence, saw many fine springs and much interesting country which would otherwise have escaped our attention.

Crossing the divide, we at once descended a steep declivity 1,000 feet into a valley about ten miles below the extreme source of the East Fork, and there camped for the night. The next morning, August 1, there was a heavy frost and ice a sixteenth of an inch thick. The thermometer frequently falls to 26° during the months of July, August, and September. The East Fork, near the point where we struck it, is about 30 feet wide and, on an average, 10 feet deep. The water flows with great velocity, is quite warm, 60° to 70°, at one camp 78°, and is fed almost entirely by warm or hot springs. The entire valley, from its source to its junction with the Madison, extending over an area twenty-five miles long and an average of half a mile in width, is covered with the siliceous deposits of the hot springs, ancient or modern. The bed of the stream is lined with the white silica, and the valley itself looks like an

alkali flat. The springs which issue from the base of the mountains on either side cause the bottom to be marshy or boggy, in many places rendering the traveling difficult. The plateau ridges which wall the valley in on either side rise to the height of 1,000 to 1,200 feet, and are covered with a dense growth of pines, not large, seldom more than 24 to 30 inches in diameter, averaging not more than 10 inches, but rising as straight as an arrow to the height of 100 to 150 feet, and growing so thickly together that it was with great difficulty we could pass among them with our pack-animals.

Among the foot-hills on the south side of the East Fork, about two miles above our camp, we found quite an interesting group of springs in a more or less active state. The basis material of the deposit is the silica, snowy white; but here and there, are quite extensive deposits of sulphur. All the steam vents are lined with sulphur, and the little streams which flow along the valley with the aggregated waters are lined with the silica, or tinged with the most delicate cream color. There are perhaps thirty or forty springs in this group. I will note a few of them: 1. A sulphur spring, 128°. 2. Boiling spring with a circular basin 5 feet in diameter, 172°. 3. An impulsive spring that rises and falls about once a second with a jerking noise, 192°. 4. Throws out quite a stream of water, 12 inches wide and 2 inches deep; the basin and channel are most delicately lined with sulphur, 182°. 5. A boiling sulphur spring, 189°. 6. A boiling spring, 199°. 7. 183°. There are a great number of steam vents with the orifices lined with sulphur. Underneath the crust also are found crystals of sulphur of a vivid yellow. We were not able to explore this stream to its source in the high plateau, but there are undoubtedly many of these groups of springs which we did not see. We followed the valley down to the Fire-Hole Basin, about six miles, and found scattering springs all the way. At one point we found the temperature of the water of the creek 76°. It was remarkably clear, but it was insipid, like ordinary water that has been boiled. But the abundance as well as the luxuriance of the vegetation in and around the stream was almost marvelous.

About two miles below our first camp, we passed a pretty little stream flowing down from the hills, with the channel lined with a delicate veil of creamy sulphur. We followed it up the valley a half a mile and came to another group of springs similar to those just described. There were a number of steam vents, with the same variety of delicate linings and shades of coloring. In some of the springs iron predominates over the sulphur, and to these we gave the name of Iron Springs. In others the sulphur is in excess, and those we called Sulphur Springs. We passed springs of various kinds and temperature every few yards, on either side of the creek; some deposited great quantities of iron, others sulphur, but most of them large quantities of both.

Fig. 36.

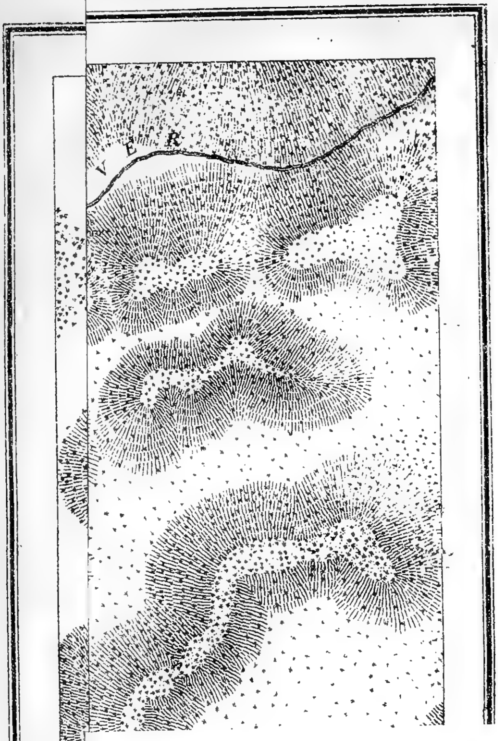
MUD POT, LOWER FIRE-HOLE BASIN.

The grades of coloring are as varied, though not as vivid. The basins of the springs are of a great variety of shapes; the tendency, however, is to a circular form. The basin of one spring is funnel-shaped, circular, 5 feet in diameter, the water as clear as crystal, and 30 feet in depth. 2.

With a funnel 2½ feet in diameter, circular, tapering down to four inches in diameter, with the sides lined with a delicate white enamel, like porcelain, a most beautiful spring, 170°. 3. Oblong basin 5 by 15 feet, 158°, clear water, unknown depth. 4. Mud-spring, 12 inches in diameter, bubbling like mush, 190°. (Fig. 36.) There are many more which lie along the margin of the stream, the raised craters dotting the surface in many places. Some of them have a temperature as low as 112°, 116°, 125°, and yet are constantly but slightly agitated by the bubbles rising to the surface, so that they might be classed as bubbling springs. Our second camp, on the East Fork, August 2 and 3, comes within the limit of the chart of the Lower Geyser Basin, just below the thickest group on the south side of the same stream.

Early in the morning of the 3d, we commenced the survey of the group of springs near our camp. In the description of the springs of this entire basin, I will refer to the chart, and the course of our examinations may be traced with great ease. We described briefly each spring, ascertained its temperature, and located it topographically. In the morning the steam ascends from over a hundred orifices, reminding one at once of Mr. Langford's comparison of a factory village.

I will here give short specific descriptions of the most important and characteristic springs of this group, and then pass on to the Fire-Hole Valley. 1. Clear water, bubbling, basin 8 feet in diameter, 4 feet deep, silica, iron, and some sulphur, 125°. 2. Bubbling up slightly, 4 feet in diameter, 6 feet deep, no rim, 112°. 3. Silica and iron very abundant, 189°. 4. Bubbling most beautifully, basin 2 by 3 feet, with small steam orifices all around, extensive overflow of water, 176°. 5. Small but elegantly ornamented, 12 by 18 inches, silica and iron, with green vegetable matter. 6. Beautifully scalloped orifice or funnel, 2 by 3 feet, the thin siliceous shell or crust projects over the funnel all around. 7. A large and beautiful spring, circular, 15 feet in diameter, 5 feet deep, with a thick deposit of iron all around the sides of the basin and on the surface where the surplus water flows, 125°. 8. Two springs near together, 142° and 134°, with much iron, with beautiful rim, 6 feet in diameter, with funnel-shaped orifices; second one with basin 10 by 15 feet, 10 feet deep, water clear as crystal. 9. Orifice runs straight down to an unknown depth, 4 feet in diameter, 169°. Leaves of trees in the basin are frosted all over with silica as white as snow. The delicate bead-like embroidery over the inner surface of the basin, as seen through the clear waters, is a marvel of beauty. 10. A scolloped rim, much ornamented, 197°, a kind of spouting geyser; the water rises up in the orifice, boils violently for a few moments, and then sinks down again. 11. Continually throws up its contents 6 to 12 inches, 192°. 12. Boils with a suppressed gurgle, boiling up about 4 inches, shoots up at times 6 to 10 inches, a small locomotive spring. 13. The most beautiful of all in this group, 128°, main basin 10 by 15 feet, water marvelously transparent, of a most delicate blue. As the surface is stirred by the passing breeze, all the colors of the prism are shown, literally a series of rainbows. We called the most delicately colored springs, Prismatic Springs. In the basin yet to be described, are several of these prismatic springs of marvelous beauty, and the striking vividness of the colors, Lieutenant Doane has aptly likened to the stage representations of "Alladin's Cave," and the "House of the Dragon Fly." I was at once reminded of the wonderful coloring produced on the stage at one of the modern spectacular exhibitions, but nothing ever conceived by human art could equal the peculiar vividness and delicacy of coloring of these remarkable prismatic springs. The inner sides are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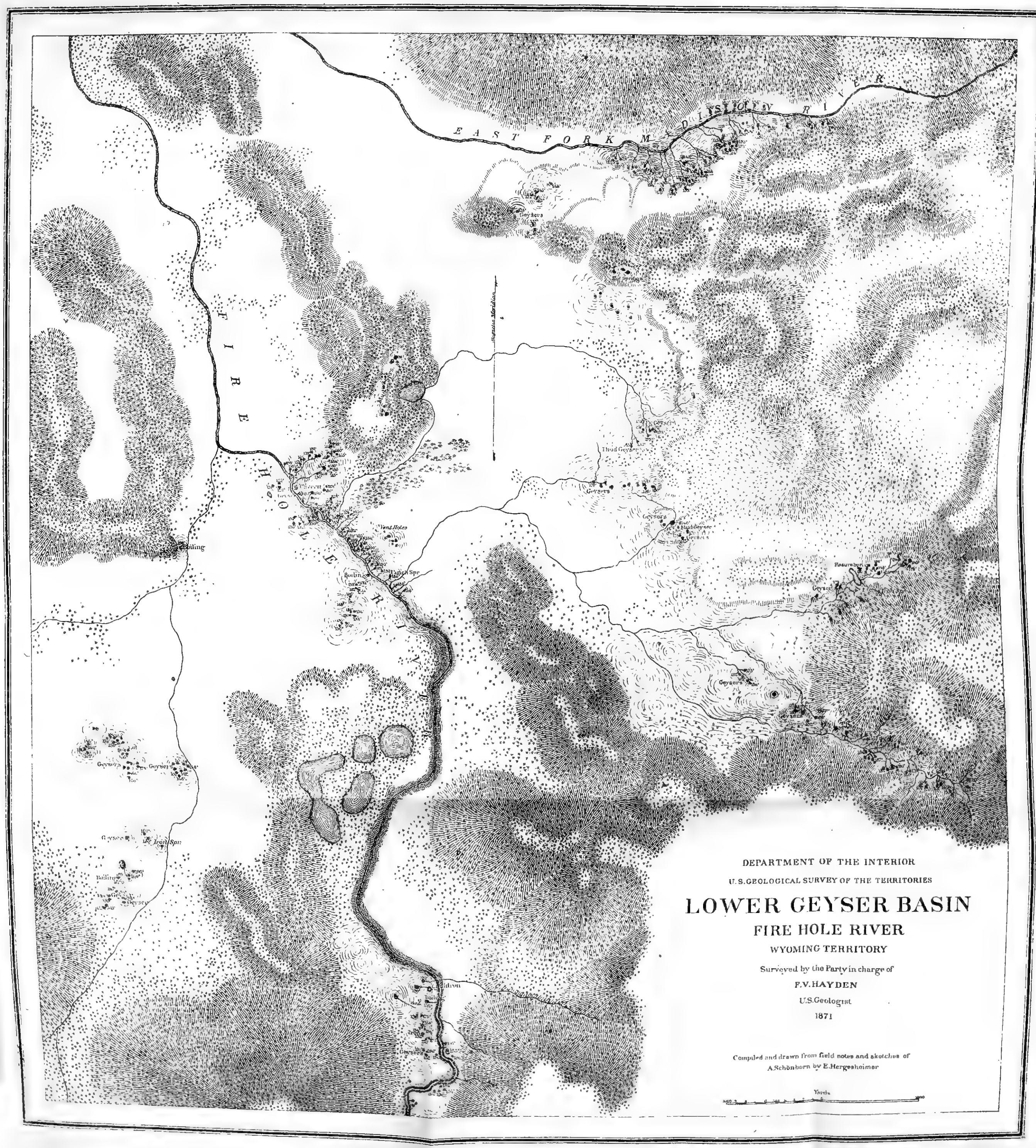
DEPARTMENT OF THE INTERIOR
U.S.GEOLOGICAL SURVEY OF THE TERRITORIES
LOWER GEYSER BASIN
FIRE HOLE RIVER
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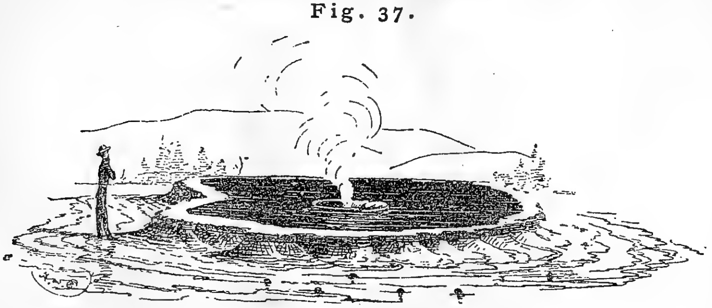
EAST FORK MADISON RIVER
FIRE HOLE RIVER
Geysers
Vent Holes
Iron Spr

covered with the snow-white silica, which in the beauty and completeness of the ornamentation surpasses the most intricate embroidery or frost-work. About a mile south of the East Fork, on the head of a little stream that flows into the Fire-Hole River, is another of these beautiful prismatic springs, which we called the Rainbow Springs. A thin delicately ornamental rim of silica surrounds a basin 6 feet in diameter, filled to the margin with perfectly clear water, and as the morning sunlight falls upon it, it reflects all the colors of the prism, 156°.

Before leaving the group on the East Fork I will allude to a few more that present some peculiarities. One spring keeps up an irregular spouting. It commences quite strong and violent for about a minute, throwing the water up about two feet, then it recedes into its crater with a kind of cavernous gurgle, 193°. Another small geyser operates constantly with a kind of subdued gurgle, 178°. Another gives forth a suppressed, low, continuous gurgle, like that of a kettle of boiling mush, 193°. Not unfrequently there are three, and even five orifices in a single basin, totally unconnected with each other. Sometimes one of them will be perfectly quiescent while the others are in operation, and sometimes all are going at the same time. Sometimes a dead or dying spring will be in close proximity to an active geyser, or a calm spring, with a temperature of 180° or 185°. Those springs that have a temperature of 180° and upward, present the delicate bead or frost work of silica on the inner sides of the basin, but when it is diminished to 150°, or below, a thick coating of iron is deposited. Many of the old springs have much the appearance of huge tan-vats. In some of the basins the leathery lining of the sides becomes torn into fragments, which wave to and fro at every movement of the waters. These leathery masses, which are perfectly fragile in texture, like pulp in the water, become hard like pieces of bark when dry, and are blown about by the wind. It is probably composed of diatoms aggregated together, as the vegetable scum upon a stagnant pool and covered, and perhaps the texture filled, with the particles of oxide of iron. Between the East Fork and the Fire-Hole Branch, a tongue or ridge extends down for a short distance from the main range, composed mostly of a gray or yellowish-gray siliceous material; evidently an old hot-spring deposit. The trachytic basalt also crops out here and there, and, up in the higher portions of the mountains,

Fig. 37.



CRATER OF THUD GEYSER IN LOWER FIRE-HOLE IMMEDIATALY AFTER ERUPTION, LOWER GEYSER BASIN.

prevails altogether. The broken hills that make up this ridge show, however, that the history of these springs dates far back to the period of volcanic activity, for the spring-deposits—conglomerates, volcanic breccia, and trachyte—are all mingled together. High up in the hills, on the south side of the ridge, are a few springs, which, in the early morning, send up large columns of steam.

We then passed over an area of a mile in width, covered with a

white crust, with a few scattered springs, mostly dead. The first group does not differ materially from those described on the East Fork. The aggregated waters form a little stream, which flows westward into a small lake in a grove of pines; thence southwest into the Fire-Hole River. (Fig. 37.) One of the springs we named the Thumping or Thud Geyser, from the dull, suppressed sound which is given off as the water rises and recedes. The orifice has a beautifully scalloped rim, with small basins around it, 185°. There is also a long fissure-spring, the opening 40 feet long, 4 feet wide, and 10 feet deep, clear as crystal, 175°. Also a large basin nearly circular, 50 feet in diameter, with a number of huge apertures, some of which throw the water up 30 feet. From one orifice the water shoots up continually 4 to 6 feet. All around this geyser-group are several smaller springs continually bubbling. There are also a number of reservoirs once in an active state. There are large numbers of small geysers, some constantly shooting up 2 to 10 feet; others in a violent state of ebullition, rising and falling; the latter might be called pulsating springs. There is one beautiful spring, with a basin so large that it looks like a small lake, 25 by 30 feet, and one can look from the margin down into its clear depths for over

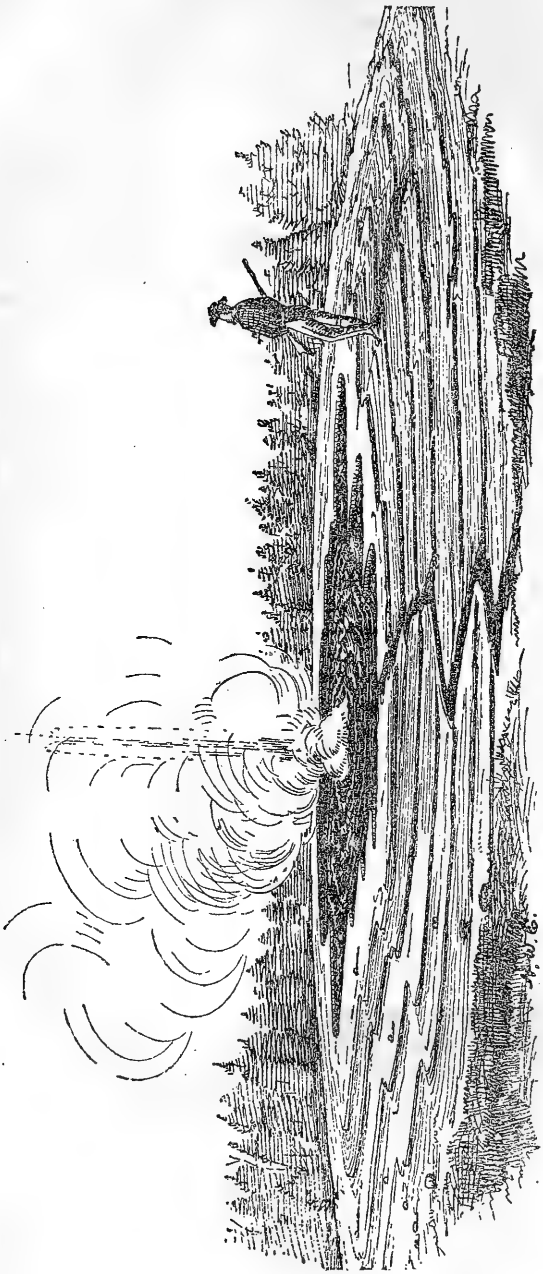


Fig. 38.

FOUNTAIN GEYSER, LOWER FIRE-HOLE.

30 feet and behold a fairy-like palace, adorned with more brilliant colors and decorations than any structure made by human hands. South of the Thud Geyser, as laid down on the chart, there is one large basin, 150 feet in diameter, with a crater within the rim 25 feet in diameter. From this inner orifice the entire mass of water is thrown up 30 to 60 feet, falling back into it, in detached globules, like silver. There is a rim around the inner crater 3 feet high. The vast column of water as it shoots up, spreads out in falling back, like a natural fountain, so that it overflows the inner rim for a radius of 10 feet. (Fig. 38.) A short distance south of the Fountain Geyser is one of the most remarkable mud-pots in the Fire-Hole Valley. (Fig. 39.) The diameter within the rim is 40 by 60 feet, and forms a vast mortar-bed of the finest material. The surface is covered with large puffs, and as each one bursts the mud spirts upward several feet with a suppressed thud. The mud is an impalpable, siliceous clay, fine enough, it would seem, for the manufacture of the choicest ware. The colors are of every shade, from the purest white to a bright, rich pink. The surface is covered

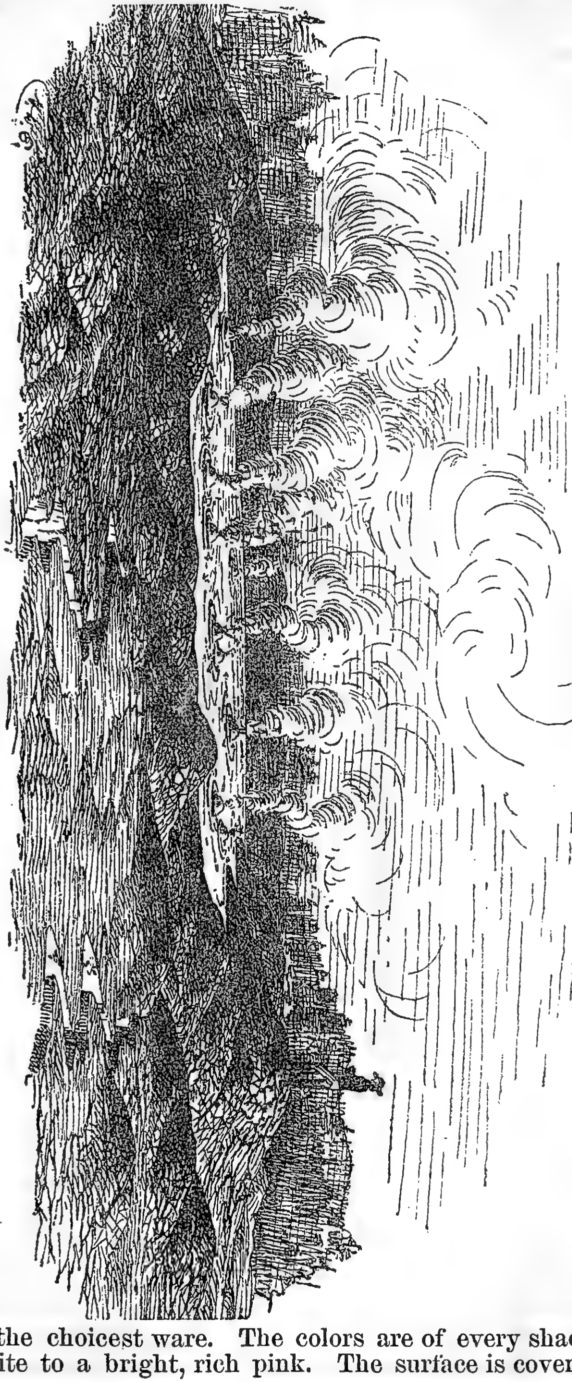


Fig. 39.

MUD PUFF, LOWER FIRE-HOLE.

with twenty or thirty of these puffs, which are bursting each second, tossing the mud in every direction on to the broad rounded rim. There are several other mud-puffs in the vicinity, but they do not differ materially from the last, except in size. Within a few feet of the mud-spring, there is a large clear spring, 40 by 60 feet, with perhaps fifty centers of ebullition, filled with the rusty leathery deposit, and all around the basin where the waters overflow there is an extensive deposit of the iron. The temperature is 140°. About one-fourth of a mile west of the large mud-pots are some extensive fissure-springs, one of them 100 feet long and of variable width, 4 to 10 feet. These appear to be merely openings in the crust or deposit which covers the entire surface. Quite a large stream flows from this spring. Many of the springs seem to remain full to the rim of the crater, and are in a continual state of greater or less ebullition, and yet no water flows from them. Others discharge great quantities. The aggregate of the surplus water usually forms a good sized stream, as is shown on the map. In this group are a few springs that have precipitated a small amount of sulphur, the first observed in the Fire-Hole Valley. (Fig. 40.) Silica and iron seem to be the dominant constituent in nearly all the deposits. There are numerous springs that deposit a curious black sediment like fine gun-powder, and send forth a very disagreeable odor. On the southeast side of the basin, it will be seen by reference to the chart, that there is a long group of springs extending high up into the mountains. This is a most interesting group, and many of them are of the largest size. There are not many geysers, and none of the first class, yet nearly all of them are in a more or less intense state of ebullition, shooting up a column of water varying from a few inches to 8 or 10 feet. Many of them are surrounded with a deposit tinged with the brightest of pink and rose tints from the oxide of iron. The aggre-

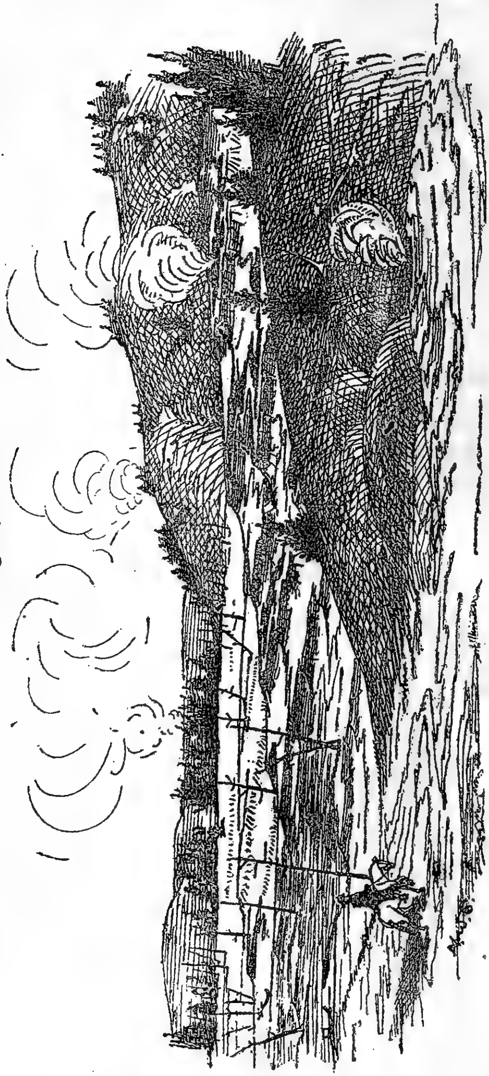


Fig. 40.

OVERFLOW DOWN RAVINE FROM STEADY GEYSER, UPPER GEYSER BASIN.

gated waters leave the little lake, and flow down with considerable rapidity toward the Fire-Hole, by steps or terraces; each step or terrace forms a pool with its beautiful scalloped rim, from the notched

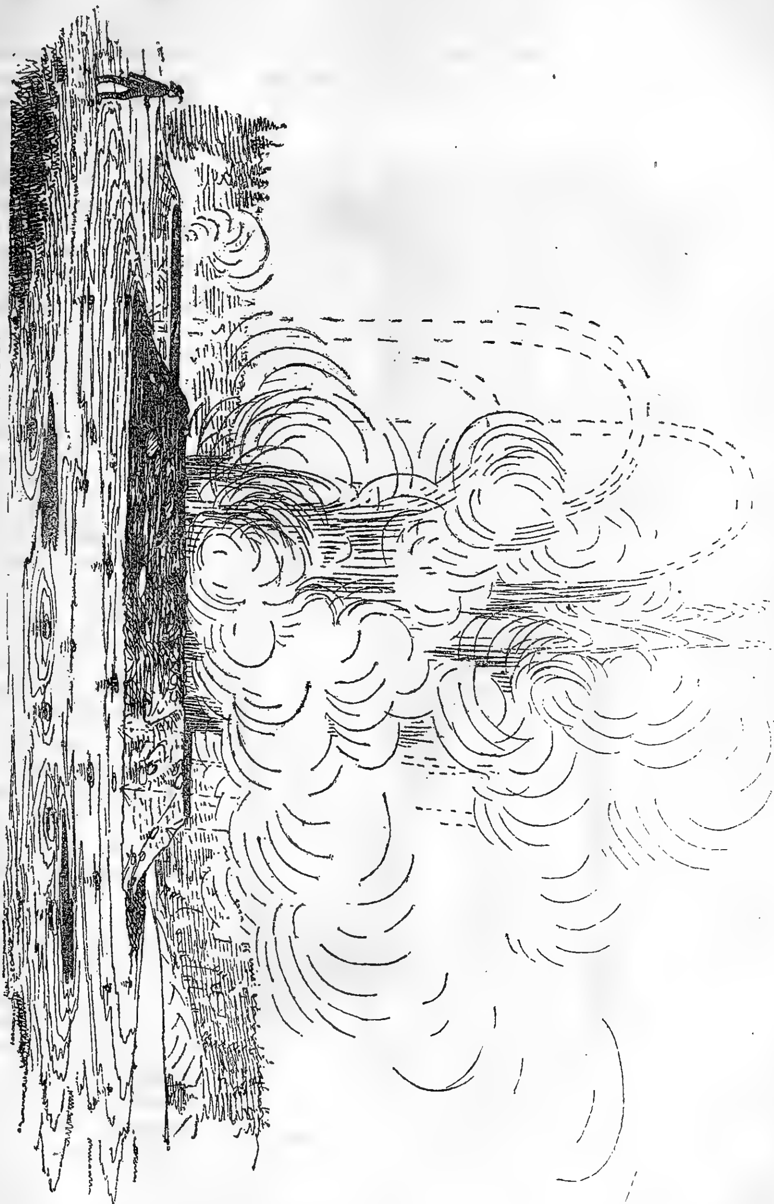


Fig. 41.

ARCHITECTURAL FOUNTAIN, LOWER GEYSER BASIN.

edges of which the water flows on to successive terraces. In one of the streams, the channel of which is about two feet wide and one foot deep, the water was filled with a plant with a yellowish-pink base, bordered with a very fine green silky fringe, and these fringes, or cilia, were per-

petually vibrating with the flowing waters. Except that they were a rich vegetable green, these fringes had the form and texture of the finest cashmere wool. The luxuriant growth of vegetation in and along the borders of these little streams was a wonder of beauty. The whole view was there superior to anything of the kind I had seen. In this group greatly is one cone with the top broken off, 18 inches high, 4 feet in diameter, with an aperature at the top 18 inches in diameter, in a constant state of ebullition. From the form of the crater we called this the Bee-Hive. In the lower basin there are very few of the raised craters, but mostly conical, funnel-shaped basins, with rims of various forms. The majority of them are circular or nearly so. All around the Bee-Hive for several feet the surface is ornamented with pearly tubercles of silica, from the size of a pea to three inches in diameter. The valley is filled with springs up to its very source, and those springs which burst from the mountain side 800 feet above the sea have temperatures respectively of 166°, 175°, and 180°. On the south side of the cañon, flowing down the almost vertical side of the mountain, there was a little cool spring so imbedded in its bright green carpet of moss that it could hardly be seen. With great difficulty we managed to climb up the mountain side, and, clearing away the moss, obtained the first water that we could drink for eight hours. In all of our examination during the day we had not found a drop of water of sufficiently low temperature to take into our mouths, though there were hundreds of the most beautiful springs all around us. We were like Coleridge's mariner in the great ocean, "Water, water everywhere, but not a drop to drink." There is every variety of form here to the basins of the springs. One is a fine boiling spring with a nearly circular rim 5 by

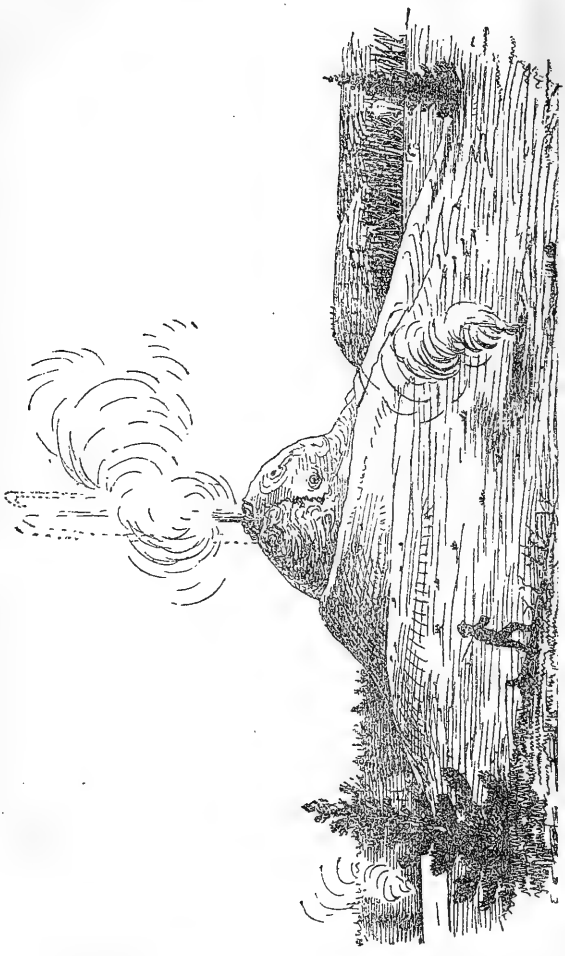


Fig. 42.

WHITE DOME, LOWER GEYSER BASIN.

8 feet, running straight down beyond the reach of vision. Another is funnel-shaped, tapering down to a mere aperture, with the thin scalloped rim projecting over the water all around for several inches. Some have no water flowing from them; others send forth a stream two feet wide and six inches deep. These springs vary in temperature all the way from 197° to 140°. About half of the springs were not considered worthy of attention and are not located on the chart. In the lower portions of this group, there is one of the handsomest foun-

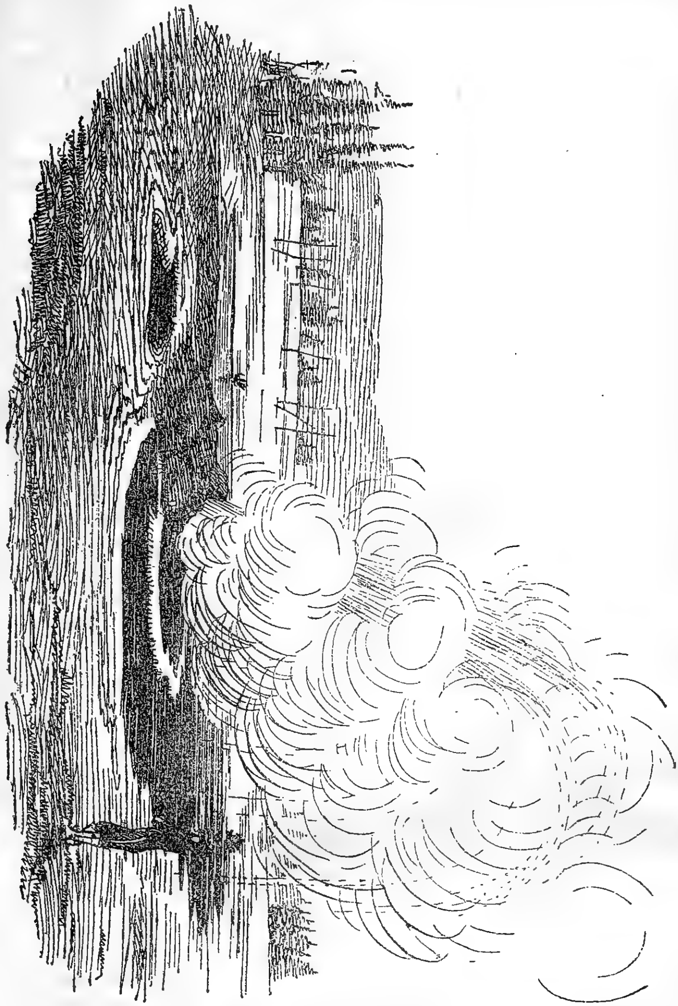


Fig. 43.

STEADY GEYSER, LOWER FIRE-HOLE.

tain-springs. The basin is most elegantly scalloped, nearly circular, 25 feet in diameter, with vertical sides to an unknown depth. The entire mass of the water is at times most violently agitated, and, overflowing the sides of the basin, passes off in a kind of terrace pools or reservoirs to the main stream, producing a system of architecture out of silica similar to that of the calcareous springs on Gardiner's River. (Fig. 41.) The gay colors, from bright pink to delicate rose, are well shown. Near this fountain is one of the elevated craters, which we

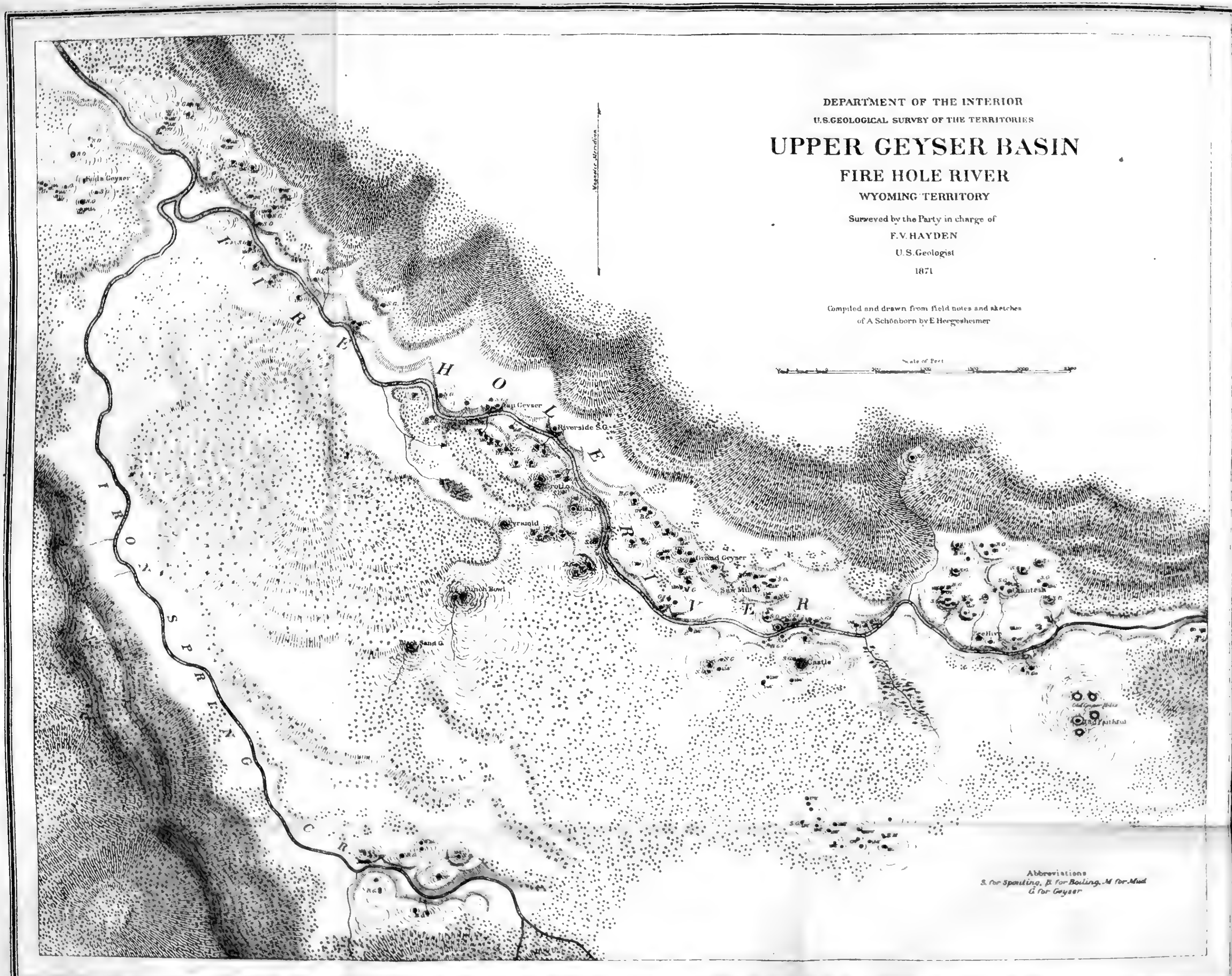
called the White Dome Geyser. (Fig. 42.) The broad mound is 15 feet high, and upon this is a chimney about 20 feet in height. The steam issues steadily from the top like a high-pressure engine.

Early in the morning of August 30, the valley was literally filled with columns of steam, ascending from more than a thousand vents. I can compare the view to nothing but that of some manufacturing city like Pittsburgh, as seen from a high point, except that instead of the black coal smoke, there are here the white delicate clouds of steam. (Fig. 43.) Small groups or solitary springs that are scattered everywhere in the woods, upon the mountain-sides, and which would otherwise have escaped observation, are detected by the columns of steam. It is evident that some of these groups of springs have changed their base of operations within a comparatively recent period; for about midway on the east side of the lower basin there is a large area covered with a thick, apparently modern, deposit of the silica, as white as snow, while standing quite thickly all around are the dead pines, which appear to have been destroyed by the excessive overflow of the water and the increased deposition. These dry trees have a most desolate look; many of them have fallen down and are incrusted with the silica, while portions that have fallen into the boiling springs have been reduced to a pulp. This seems to be one of the conditions of silicification, for when these pulpy masses of wood are permitted to dry by the cessation of the springs, the most perfect specimens of petrified wood are the result. In one instance a green pine-tree had fallen so as to immerse its thick top in a large hot basin, and leaves, twigs, and cones had become completely incrusted with the white silica, and a portion had entered into the cellular structure, so that when removed from the water, and dried in the sun, very fair specimens were obtained. Members of my party obtained specimens of pine cones that were sufficiently silicified to be packed away among the collections.

Fig. 44.

CATFISH GEYSER.

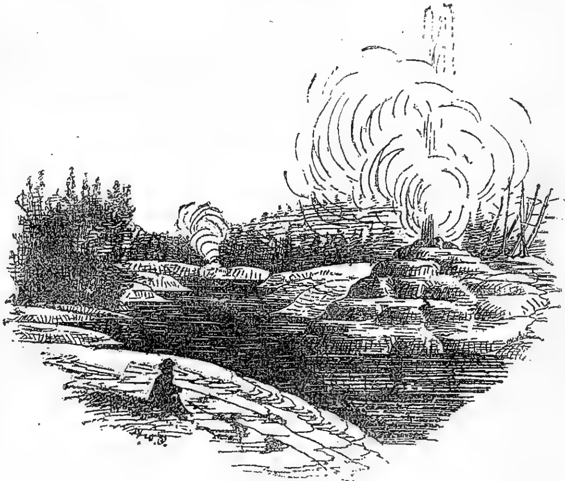
In order that we might get a complete view of the Lower Geyser Basin, from some high point, we made a trip to the summit of Twin Buttes, on the west side of the basin. From the top of one of these buttes, which is 630 feet above the Fire-Hole River, we obtained a bird's-eye view of the entire lower portion of the valley, which was estimated to be about twenty miles long and five miles wide. To the westward, among the mountains, were a number of little lakes, which were covered with a huge species of water-lily, *Nuphar advena*. The little streams precipitated their waters in the most picturesque cascades or falls. One of them was named by Colonel Barlow the Fairy Fall, from the graceful beauty with which the little stream dropped down a clear descent of 250 feet. It is only from a high point that it can be seen, for the water falls gently down from the lofty overhanging cliff into a basin at the foot, which is surrounded by a line of tall pines 100 to 150 feet in height. The continual flow of the



DEPARTMENT OF THE INTERIOR
U.S.GEOLOGICAL SURVEY OF THE TERRITORIES
UPPER GEYSER BASIN
FIRE HOLE RIVER
WYOMING TERRITORY
Surveyed by the Party in charge of
F.V.HAYDEN
U.S.Geologist
1871
Compiled and drawn from field notes and sketches
of A Schönborn by E Hergesheimer
Scale of Feet
Magnetic Meridian
FIRE HOLE RIVER
IRON SPRING CR
Riverside S.G.
Grotto
Giant
Pyramid
Grand Geyser
Saw Mill
Punch Bowl
Black Sand G.
Castle
Bee Hive
Old Geyser Holes
Old Faithful
Abbreviations
S. for Spouting, B. for Boiling, M. for Mud
G. for Geyser

waters of this little fountain has worn a deep channel or furrow into the vertical sides of the mountain. The Twin Buttes are two conical mountains, partially separated from the main range, and on the summit, a few vents are sending forth their columns of steam. As far as the eye can reach, can be seen the peculiar plateau mountain ranges, black with the dense forests of pine, averaging from 9,000 to 10,000 feet above sea-level. On the west side of the Fire-Hole, near its margin, are four small lakes with quiet surfaces, with water as blue as the sky. One of them is about half a mile in length. The waters are cold at the present time, but the basins present the appearance of having been enormous hot springs at some period in the past. From our camp on the main branch that enters the Fire-Hole at the upper end of the lower group of springs on the borders of the rim, we made our examinations down the stream, descending the east side and returning on the opposite side, and then passing up the west branch, noting all the springs of importance, taking the temperatures, and securing brief descriptions of their peculiarities. Most of them do not differ materially from those already described, so that I shall notice only the most important. The numbers of the vents can be understood by reference to the chart, although many of the less important and dead springs are omitted. The first one we shall notice is located on the right branch of the river, and from the triangular shape of its basin, 8 by 10 feet, we named it the "Conch Spring." All along the margins of the river hundreds of springs, which we could not note, but which aid in swelling the volume of the stream, issue from beneath the siliceous crust. A little below the Conch Spring, on the very margin of the river, there is a fine geyser, which has built for itself a crater three feet high, with a shell a foot thick. The inside of the crater is about six feet in diameter, and the entire mass of water is in a constant state of agitation. Sometimes it will boil up so violently as to throw the entire mass up four feet, and then die down so as to boil like a caldron. Indeed, the whole process might be imitated by subjecting a caldron of water to continuous and excessive heat. The water is perfectly clear, and the overflow forms a stream six inches wide and two inches deep, passing down the sides of the crater and thence into the river along the most exquisitely decorated channel. The entire surface of the crater is covered with pearl-like beads, formed by the spray of the waters. A section of the crater shows it to have been built up very slowly, in very thin laminæ. Another spring, with a crater like a horn, about a foot in diameter at the top and six feet at the base, we called the Horn Geyser. It is in a constant state of ebullition, with the same ornamenta

Fig. 45.

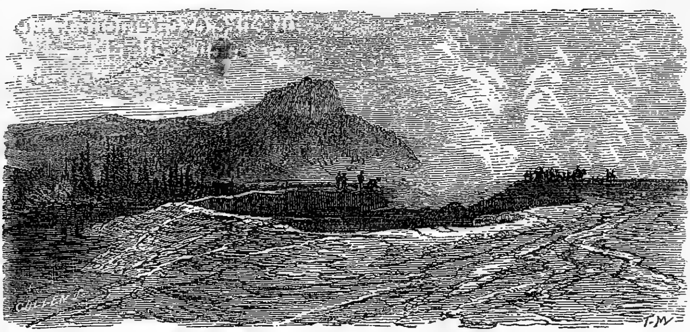


RIVERSIDE GEYSER, UPPER GEYSER BASIN.

tions as the one just described. A spring on a level with the river has an enormous square basin, 30 feet across, of unknown depth. We called this the Bath Spring. A little below is another singular form of wonderful beauty. The water issues from beneath the crust near the margin of the river from several apertures. The basin itself is 15 by 20 feet and 20 feet deep. It seemed to me that nothing could exceed the transparent clearness of the water. The slightest object was reflected in its clear depths, and the bright blue tints were indescribable. We called this the Cavern. The mud springs are also numerous and important in this group. As usual, they are of all sizes, from an inch or two to 20 or 30 feet in diameter, with contents varying from mere turbid water to stiff mud. They seldom have any visible outlet, but are in a constant state of agitation, with a sound which varies with the consistency of the contents. There are several of the mud-pots which give off a suppressed thud as the gases burst their way through the stiff mortar. Sometimes the mortar is as white as snow, or brown, or tinged with a variety of vivid colors. One mud-spring, located in the woods near a small lake on the east side of the Fire-Hole, has a basin 30 by 40 feet, with sides 15 feet high, in constant action, frequently hurling the mud outside of the rim. All around it are a number of little vents, which keep up a simmering noise, some of which have built up little cones 4 to 12 inches high, which have in many cases closed themselves up at the top and ceased. On removing the cone, we found the inner sides lined with the delicate crystals of sulphur. The last stage of these springs, in many cases, seems to be a steam-vent, at which time the sulphur is deposited. On the west side of the Fire-Hole, and along the little branch that flows into it from the west, are numbers of springs of all grades, and the broad bottom is covered with a snow-white siliceous crust. Near the base of the mountains, there is a massive, first-class boiling spring, in a constant state of violent agitation, sending forth great columns of steam, with a singular toad-stool rim. There are some springs around which the siliceous deposits have assumed a form like the toad-stool fungus. It flows out from beneath a hill 150 feet high, composed of a kind of stratified cement, which was certainly deposited in the lake when these hot springs were in active operation. It is undoubtedly formed of volcanic *ejectamenta* mingled with the deposits from the hot springs; 196°. There are some that might be called spasmodic springs. There is one massive spring, with a most beautifully scalloped rim 15 by 20 feet, which is always agitated, but occasionally shoots up several feet with great violence; 196°. About three miles up the Fire-Hole we meet with a small but quite interesting group of springs on both sides of the stream. There is a vast accumulation of silica, forming a hill 50 feet along the level of the river; upon the summit is one of the largest springs yet seen, nearly circular, 150 feet in diameter, boils up in the center, but overflows with such uniformity on all sides as to admit of the formation of no real rim, but forming a succession of little ornamental steps, from one to three inches in height, just as water would congeal from cold in flowing down a gentle declivity. There was the same transparent clearness, the same brilliancy of coloring to the waters, but the hot steam and the thinness of the rim prevented me from approaching it near enough to ascertain its temperature or observe its depth, except at one edge, where it was 180°. It is certainly one of the grandest hot springs ever seen by human eye. (Fig. 46.) But the most formidable one of all is near the margin of the river. It seems to have broken out close by the river, and to have continually enlarged its orifice by the breaking down of its sides. It evidently commenced on the east side,

and the continual wear of the under side of the crust on the west side has caused the margin to fall in, until an aperture at least 250 feet in diameter has been formed, with walls or sides 20 to 30 feet high, showing the laminæ of deposition perfectly. The water is intensely agitated all the time, boiling like a caldron, from which a vast column of steam is ever arising, filling the orifice. As the passing breeze sweeps it away for a moment, one looks down into this terrible seething pit with terror. All around the sides are large masses of the siliceous crust that have fallen from the rim. An immense column of water flows out of this caldron into the river. As it pours over the marginal slope, it descends by numerous small channels, with a large number of smaller ones spreading over a broad surface, and the marvelous beauty of the strikingly vivid coloring far surpasses anything of the kind we have seen in this land of wondrous beauty; every possible shade of color, from the vivid scarlet to a bright rose, and every shade of yellow to delicate cream, mingled with vivid green from minute vegetation. Some of the channels were lined with a very fine, delicate yellow, silky material, which vibrates at every movement of the waters. Mr. Thomas Moran, the distinguished artist, obtained studies of these beautiful springs and from his well-known reputation as a colorist, we look for a painting that will convey some conception to the mind of the exquisite variety of colors around this spring. There was one most beautiful funnel-shaped spring, 20 feet in diameter at the top, but tapering

Fig. 46.



GREAT SPRING, FIRE-HOLE RIVER.

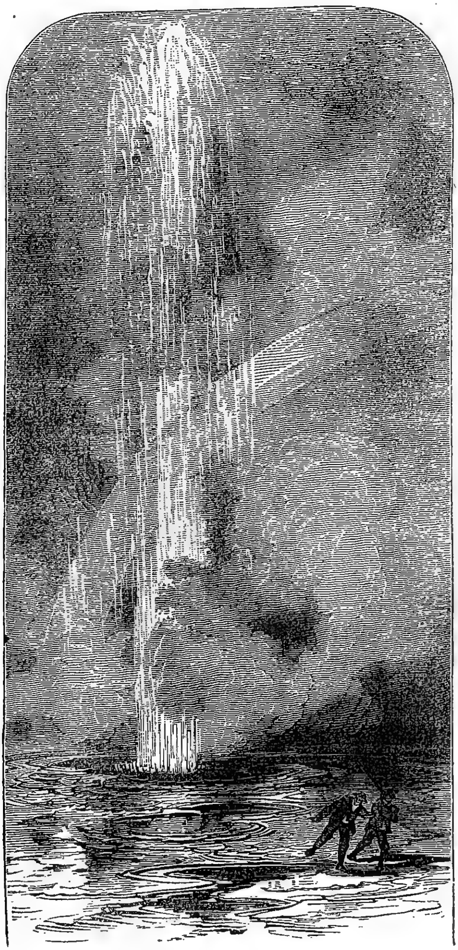
down, lined inside and outside with the most delicate decorations. Indeed, to one looking down into its clear depths, it seemed like a fairy palace. The same jelly-like substance or pulp to which I have before alluded, covers a large area with the various shades of light-red and green. The surface yields to the tread like a cushion. It is about two inches in thickness, and although seldom so tenacious as to hold together, yet it may be taken up in quite large masses, and when it becomes dry it is blown about by the wind like fragments of variegated lichens.

At the upper end of the lower district are three immense boiling springs on the east margin of the river, and on the opposite side are two or three more, and then comes a long interval of two or three miles which is entirely free from springs, until we reach the upper basin. The immediate valley is covered with old siliceous deposits up to the base of the hills on either side, showing that, although there are no springs at this time, it was once the scene of great activity. The bottom over which the river flows is paved with the old silica. The forest grows close down to the margin of the river, and in one place the hills of trachyte almost close in the valley. High up on either side are walls

of trachyte apparently stratified and inclining 10° to 15° from the valley. The vegetation grows remarkably rank along the streams and in the valley where the crust of silica does not prevent it. The perpetual warmth caused by the proximity of the springs is undoubtedly very favorable to the growth of plants.

We camped the evening of August 5, in the middle of the Upper Geyser Basin, in the midst of some of the grandest geysers in the world. Colonel Barlow and Captain Heap, of the United States Engineers, were camped on the opposite side of the Fire-Hole. Soon after reaching camp a tremendous rumbling was heard, shaking the ground in every direction, and soon a column of steam burst forth from a crater near the edge of the east side of the river. Following the steam, arose, by a succession of impulses, a column of water, apparently 6 feet in diameter, to the height of 200 feet, while the steam ascended a thousand feet or more. It would be difficult to describe the intense excitement which attended such a display. It is probable that if we could have remained in the valley several days, and become accustomed to all the preliminary warnings, the excitement would have ceased, and we could have admired calmly the marvelous ease and beauty with which this column of hot water was held up to that great height for the space of twenty minutes. After the display is over the water settles down in the basin several inches and the temperature slowly falls to 150°. We called this the Grand Geyser, for its power seemed greater than any other of which we obtained any knowledge in the valley. (Fig. 47.) There are two orifices in one basin; one of them seems to have no raised rim, and is a very modest-looking spring in a state of quiescence, and no one would for a moment suspect the power that was temporarily slumbering below. The orifice is oblong, $2\frac{1}{2}$ by 4 feet, while for the space of 10 feet in every direction around it are rounded masses of silica, from a few inches to 3 feet in diameter, looking like spongiform corals. Nothing could exceed the crystal clearness of the water. This is the Grand Geyser. Within 20 feet of this orifice is a second one, of irregular quadrangular form, 15 by 25 feet; the east side of the main outer rim of reservoir extended 20 feet beyond

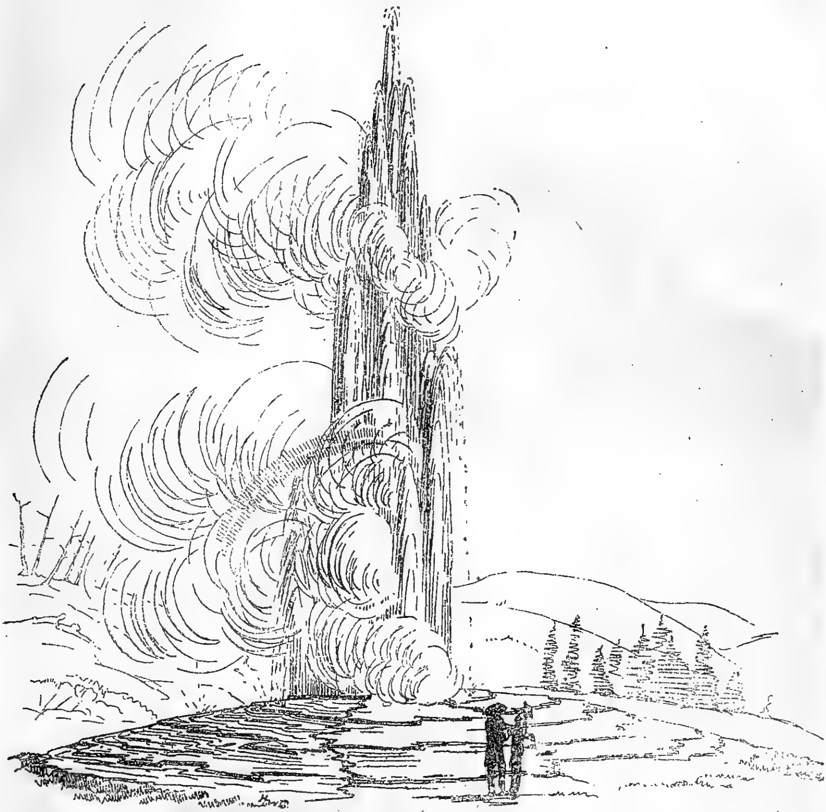
Fig. 47.



GRAND GEYSER.

the large orifice. The bottom of this great reservoir is covered with thick spongiform masses, and in addition the rim is most elegantly adorned with countless pearl-like beads, of all sizes. There are several beautiful triangular reservoirs, $1\frac{1}{2}$ by 3 feet, set around the outer sides of the rim, with numerous smaller ones, full of clear water, with

Fig. 48.



GRAND GEYSER, UPPER BASIN GEYSER, FIRE-HOLE RIVER.

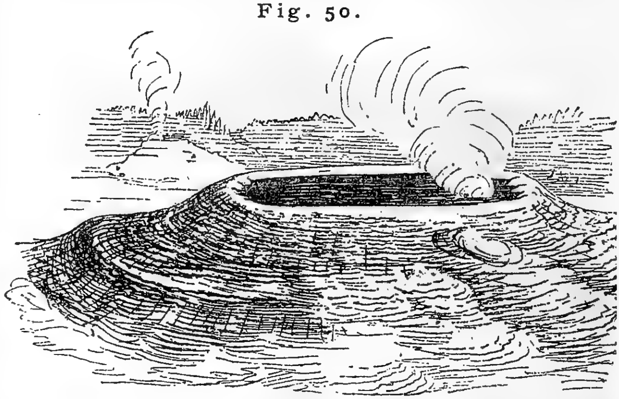
hundreds of small depressions most beautifully scalloped. As we recede from the rim, the waters as they pass slowly away produce, by evaporation, broad shallow basins, with thin, elegantly colored partitions, portions of which have the form of toad-stools. When the water settles into these depressions, or flows away toward the river in numerous small channels, the wonderful variety of coloring which is so attractive to the eye is produced. The large orifice seems to be in a state of violent agitation as often as once in twenty minutes, raising up the entire mass of water 10 or 15 feet. It is never altogether quiet. Although these two orifices are within the same rim, I could not ascertain that there is the slightest connection with each other. When the large orifice is much agitated it does not disturb the equanimity of the Grand Geyser. They both operate perfectly independent of each other. Indeed, I do not know that there is a connection between any of the springs in the whole basin, though there may be in some rare cases. The Grand Geyser operated twice while we were in the basin, with an interval of

about thirty-two hours; of course, the displays could not be exactly periodic, but it would be an interesting study to remain several days and watch carefully the movements of such a power. Just east of the Grand Geyser, as located on the chart, is a moderate-sized geyser, with three smaller ones along the side of it, all playing at the same time. From the larger one, a column of water is constantly shot up 15 or 20 feet, with much the sound of the escape of the steam from a pipe. The orifice is not more than 6 inches in diameter; but with the three smaller ones playing at the same time a great commotion is excited. Near this little group are several large boiling springs, which throw up the water in the center 2 to 4 feet. These are funnel-shaped, with orifices 6 inches to 2 feet in diameter, in basins with nearly circular rims, 15 to 40 feet in diameter. About one-fourth of a mile northeast of the castle, upon a mound about 30 feet above the river, built up with thin laminæ of silica, and rounded off, rise four chimneys of different sizes, which are geysers, though perhaps not spouting extensively at this time. One is 12 inches high, nearly circular, and 3 feet in diameter; the second is oblong, 4 by 6 feet, with rather coarsely scalloped margins, with an aperture about 15 inches in diameter; the third chimney is about 3 feet high, 6 feet at the base, with an orifice nearly quadrangular, 12 inches across, with the spongiform masses inside, and covered all over with beautiful pearly beads of silica on the outside; the fourth chimney rises 5 feet above the mound, is 10 feet in diameter at the base, with an orifice 2 feet across, lined inside with the spongiform masses. This has been at one time a first-class geyser, but is now fast going to decay, a beautiful rim. The elegant bead-work on the margin and all the spongiform masses are now falling into pieces, forming great quantities of *débris* around the base of the mound. There is also one boiling spring

Fig. 49.

CRATER FORMS, FIRE-HOLE BASIN.

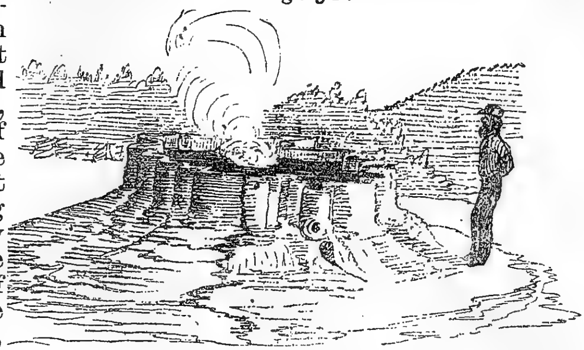
Fig. 50.



THE BATH-TUB.

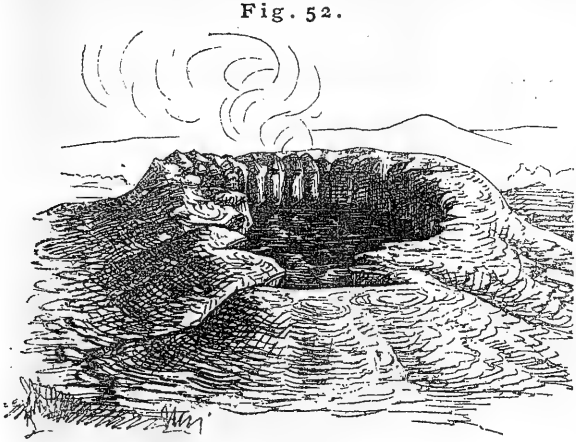
of great æsthetic beauty. The immediate orifice is nearly circular, and beautifully scalloped around the margins, extends straight down, and the water rises within an inch or two of the scalloped margin. The water is in a constant state of agitation, boiling up 2 feet at times. The margin has a coating of bright cream-yellow, while all around the surface there is the most delicate and intricate embroidering, surpassing the most elaborate lace-work. Surrounding the crater is an outer reservoir 4 feet wide, with a white and reddish-yellow rim, while in the bottom of the reservoir is the variegated sediment which aids in giving such a wonderfully gay appearance to the spring. A stream of water flows from the spring to the river, and the channel is lined for fifty yards with the variegated sediment. Near this is another mound which rises, with laminated steps, about 6 feet. I called it the Bath-Tub. (Fig. 50.) It has much the shape and size of our ordinary bathing-tubs, 5 by 10 feet, beautifully scalloped around the inner margins with the spongiform or cauliflower masses of silica inside, and the outer surface adorned with the greatest profusion of the pearly beads; the water is constantly boiling up 2 feet high, though but a small quantity flows from it. There are numerous craters or chimneys which are well worthy of attention, similar to those just described, as the Punch Bowl and Dental Cup. (Figs. 51 and 52.)

Fig. 51.



PUNCH BOWL, NO. I.

Fig. 52.



DENTAL CUP.

On the summit of the great mound, is one of a class I have called central springs; it is located on the highest point of the mound, on which this great group belongs; has a crater 20 feet in diameter, very nearly quiescent, slightly bubbling, or boils near the center, with a thin elegant rim projecting over the spring, with the water rising within a few inches of the top. The continual but very moderate overflow of this spring uniformly on every side, builds up slowly a broad-based mound, layer by layer, one-eighth to one-sixteenth of an inch thick; looking down into these springs, you seem to be gazing into fathomless depths, while the bright blue of the waters is unequaled even by the sea. There

are a number of these marvelous central springs; they usually crown the summit of a mound, with projecting rims carved with an intricate

Fig. 53.

PUNCH OWL, NO. 2.

delicacy which of itself is a marvel, and as one ascends the mound and looks down into the wonderfully clear depths, the vision is unique. The

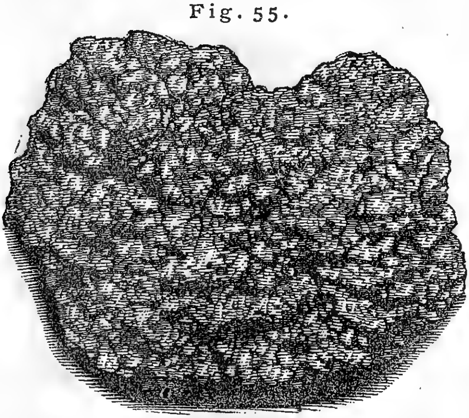
great beauty of the prismatic colors depends much on the sunlight, but about the middle of the day, when the bright rays descend nearly vertically, and a slight breeze just makes a ripple on the surface, the colors exceed comparison; when the surface is calm there is one vast chaos of colors, dancing, as it were, like the colors of a kaleidoscope. As seen through this marvelous play of colors, the decorations on the sides of the basin are lighted up with a wild, weird beauty, which wafts one at once into the land of enchantment; all the brilliant feats of fairies and genii in the Arabian Nights' Entertainments are forgotten in the actual presence of such marvelous beauty; life becomes a privilege and a blessing after one has seen and thoroughly felt these incomparable types of nature's cunning skill. There is another geyser, which has a chimney 3 feet high and 5 feet in diameter at the base, with an orifice $2\frac{1}{2}$ feet at the top, lined with the spongiform silica inside, and on the outside adorned with bead and shell work. There is a form of shell crystallization that reminds one of the artificial shell-work made with small thin oyster-shells; the form of the chimney is like an old-fashioned bee-hive. High up in the hills there is one lone spring 20 by 30 feet, with considerable flow, forming with the sediment a high mound 250 yards in diameter; it is constantly boiling up in the center about 2 feet; it has the prettily scalloped rim, and is 250 feet above the river. The group just described is a most remarkable one, and I call attention to it on the chart in which the Bee-Hive and Giantess are located.

Fig. 54.

FUNGIFORM SILICA.

We will now pass to the opposite side of the river for a moment, and examine the Castle and its surroundings. Upon the mound on which the Castle is located, there is one of the most beautiful of the calm springs, of which Mr. Jackson secured an excellent photograph; it does not boil at all, but the surface is kept in a constant vibration; the spring has a rim nearly circular, 25 by 30 feet; is somewhat funnel-shaped, passing down to a depth of 60 feet in water that has an almost unnatural clearness, to a small aperture, which leads under the shell to an unknown depth; the rim slopes down on the other side all around about 12 inches, 1 to 3 inches thick, most elegantly scalloped, the under sides in leaves like a toad-stool; the inner lining of the basin is a marvel of delicate tracery of pure

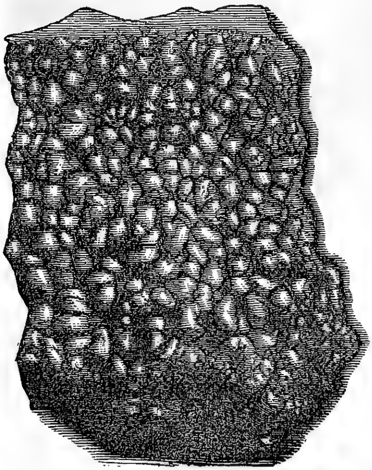
Fig. 55.



SPONGIFORM CF CAULIFLOWER SILICA.

white silica; deep down in the sides of the basin are what appear to be chambers, all finished off with the same delicate work. The Castle receives its name from its resemblance to the ruins of an old castle as one enters the valley from the east. The silica has crystallized in immense globular masses, like cauliflowers or spongiform corals; all around it the crystals seemed to have formed about a nucleus at right angles to the center; the entire mound is about 40 feet high, and the chimney 20 feet; the lower portion rises in steps formed of thin laminæ of silica, mostly very thin, but sometimes becoming compact, an inch or two thick. On the southeast side, where the water is thrown out continually, these steps are ornamented with the usual bead and shell work, with the large cauliflower-like masses, but the other portions are fast going to decay, and the *débris* are abundant; indeed, this has undoubtedly been one of the most active and powerful geysers in the basin; it still keeps up a great roaring inside, and every few moments throws out a column of water to the height of 10 or 15 feet; all around it are some most beautifully ornamented reservoirs that receive the surplus waters. If I should here describe the Giant, Grotto, Punch-Bowl, and a hundred other geysers of all classes, it would be pretty much a repetition of what has already been written. The Giant has a crater like a broken horn, and, while my party were in the basin, played at one time one hour and twenty minutes, throwing the water up to the height of 140 feet. Lieutenant Doane states that at the time of his visit the previous year it played three and a half hours, throwing a column of water 90 to 200 feet.

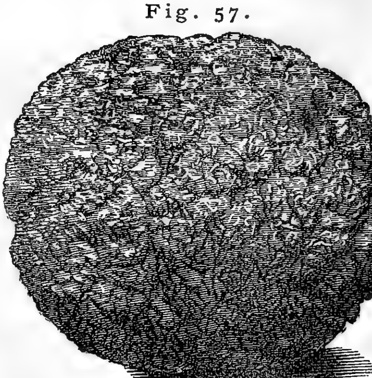
Fig. 56.



PEARLY SILICA.

"*The Giant has a rugged crater, 10 feet in diameter on the outside, with an irregular orifice 5 or 6 feet in diameter. (Fig. 58.) It discharges a vast body of water, and the only time we saw it in eruption the flow of water in a column 5 feet in diameter, and 140 feet in vertical height, continued uninterruptedly for nearly three hours. The crater resembles a miniature model of the Coliseum.

Fig. 57.



SPONGIFORM OR CAULIFLOWER SILICA.

Our search for new wonders leading us across the Fire-Hole River, we ascended a gentle incrusted slope, and came suddenly upon a large oval aperture with scalloped edges, the diameters of which were 18 and 25 feet, the sides corrugated and covered with a grayish-white siliceous deposit, which was distinctly visible at the depth of 100 feet below the surface. No water could be discovered, but we could distinctly hear it gurgling and boiling at a great distance below. Suddenly it began to rise, boiling and spluttering, and

* N. P. Langford in Scribner's Monthly for June, 1871.

sending out huge masses of steam, causing a general stampede of our company, driving us some distance from our point of observation. When within about 40 feet of the surface, it became stationary, and we returned to look down upon it. It was foaming and surging at a terrible rate, occasionally emitting small jets of hot water nearly to the mouth of the orifice. All at once it seemed seized with a fearful spasm, and rose with incredible rapidity, hardly affording us time to flee to a safe distance, when it burst from the orifice with terrific momentum, rising in a column the full size of this immense aperture to the height of 60 feet; and through and out of the apex of this vast aqueous mass, five or six lesser jets or round columns of water, varying in size from 6 to 15 inches in diameter, were projected to the marvelous height of 250 feet. These lesser jets, so much higher than the main column, and shooting through it, doubtless proceed from auxiliary pipes leading into the principal orifice near the bottom, where the explosive force is greater. If the theory that water by constant boiling becomes explosive when freed from air be true, this theory rationally accounts for all irregularities in the eruptions of the geysers.

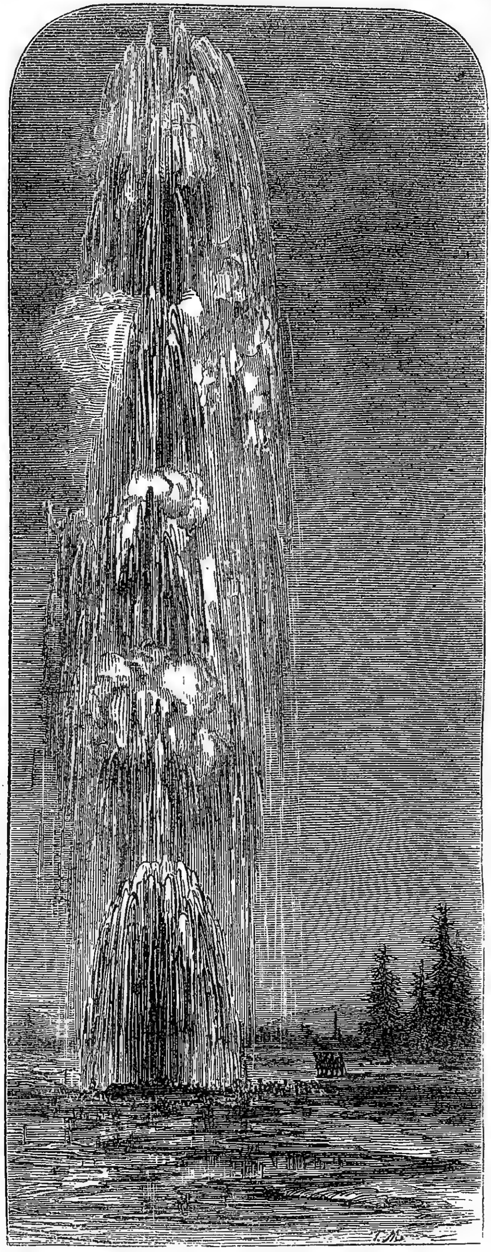
Fig. 58.

THE GIANT.

This grand eruption continued for twenty minutes, and was the most magnificent sight we ever witnessed. We were standing on the side of the geyser nearest the sun, the gleams of which filled the sparkling column of water and spray with myriads of rainbows, whose arches were constantly changing—dipping and fluttering hither and thither, and disappearing only to be succeeded by others, again and again, amid the aqueous column, while the minute globules into which the spent jets were diffused when falling sparkled like a shower of diamonds, and around every shadow which the denser clouds of vapor, interrupting the sun's rays, cast upon the column, could be seen a luminous circle radiant with all the colors of the prism, and resembling the halo of glory represented in paintings as encircling the head of Divinity. All that we had previously witnessed seemed tame in comparison with the perfect grandeur and beauty of this display. Two of these wonderful eruptions occurred during the twenty-two hours we remained in the valley. This geyser we named "The Giantess." (Fig. 59.)

A hundred yards distant from The Giantess was a siliceous cone, very symmetrical but slightly corrugated upon its exterior surface, 3 feet in height and 5 feet in diameter at its base, and having an oval orifice 24 by $36\frac{1}{2}$ inches in diameter, with scalloped edges. Not one of our company supposed that it was a geyser; and among so many wonders it had almost escaped notice. While we were at breakfast upon the morning of our departure a column of water, entirely filling the crater, shot from it, which, by accurate triangular measurement, we found to be 219 feet in height. The stream did not deflect more than four or five degrees from a vertical line, and the eruption lasted eighteen minutes. We named it "The Beehive." (Fig. 60.)

Fig.—59.



THE GIANTESS.

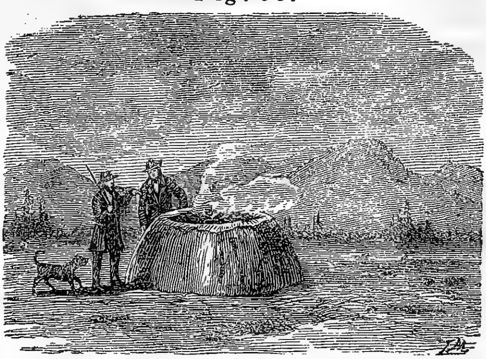
The illustration of the Giantess in action, for the use of which in this report, I am indebted to the liberality of the editors of Scribner's Monthly, shows most admirably the succession of impulses by which the column of water is held up, apparently so steadily for so long a time. We did not see this wonderful geyser in operation during our visit; but it has been so graphically described by Mr. Langford, and so faithfully depicted by Mr. Moran, the artist, that little more need be added.

The Fan Geyser consists of a group of five geysers, which play at one time, throwing the water in every direction. There is one quite conspicuous cone, marked on the chart, Pyramid, which is now extinct, except that from the summit steam is constantly escaping. This has been a geyser of some importance, and has built up a structure 25 feet high, and 100 feet in diameter at the base. Near it is a quiet spring with a most elegantly scalloped rim. It would require the careful study of a month under the most favorable circumstances to obtain full and clear information in regard to all

the geysers of this basin. I have therefore left undescribed many as interesting as those noticed in the preceding pages.

On our return to the lake from this basin, we passed up the Fire-Hole River to its source in the divide. Early in the morning, as we were leaving the valley, the grand old geyser which stands sentinel at the head of the valley gave us a magnificent parting display, and with little or no preliminary warning it shot up a column of water about 6 feet in diameter to the height of 100 to 150 feet, and by a succession of impulses seemed to hold it up steadily for the space of fifteen minutes, the great mass of water falling directly back into the basin, and flowing over the edges and down the sides in large streams. When the action ceases, the water recedes beyond sight, and nothing is heard but the occasional escape of steam until another exhibition occurs. This is one of the most accommodating geysers in the basin, and during our stay played once an hour quite regularly. On account of its apparent regularity, and its position overlooking the valley, it was called by Messrs. Langford and Doane "Old Faithful." It has built up a crater about 20 feet high around its base, and all about it are decorations similar to those previously described.

Fig. 60.



THE BEE-HIVE.

Fig. 61.

STILL HOT SPRING AND PYRAMID, UPPER GEYSER BASIN.

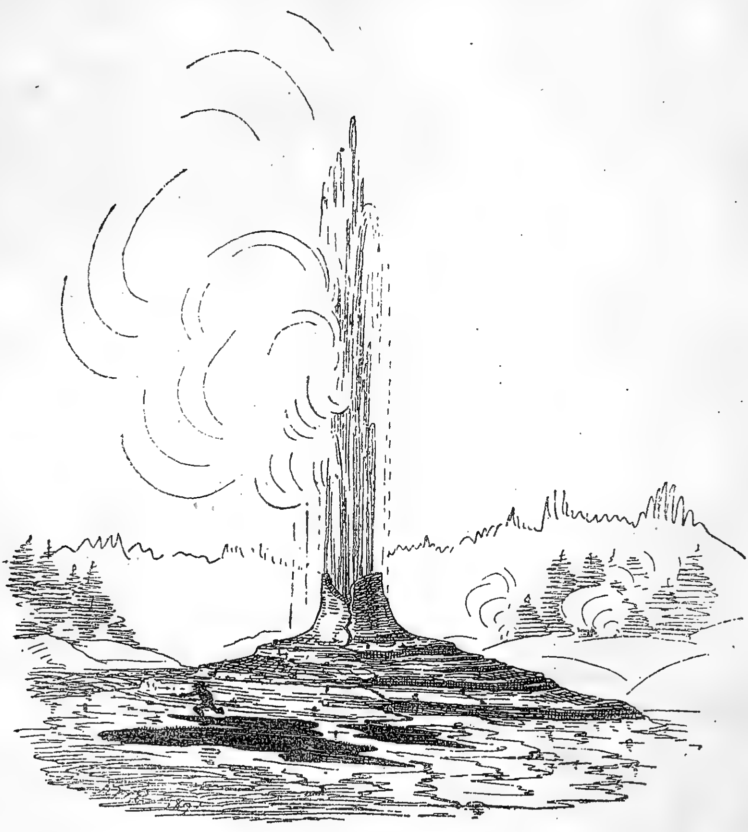
On the morning of August 6, we ascended the mountains at the head of Fire-Hole River, on our return to the hot-spring camp on the Yellowstone Lake. We had merely caught a glimpse of the wonderful physical phenomena of this remarkable valley. We had just barely gleaned a few of the surface observations, which only sharpened our desire for a larger knowledge. There is no doubt in my mind that these geysers are more powerful at certain seasons of the year than at others. We saw them in midsummer, when the surface waters are greatly diminished. In the spring, at the time of the melting of the snows, the display of the first-class geysers must be more frequent and powerful. Temperatures may vary somewhat, though those given on the chart may be relied on as correct. We left this valley, with its beautiful scenery, its hot springs and geysers, with great regret.

Mr. Elliott has sketched an ideal section of a portion of the Upper Geyser Valley, (Fig. 63,) which may convey a clearer conception of the way in which we may suppose the waters of many of the springs reach the surface. The lower portion of the section is basalt, then lake

or local drift deposits, and thirdly the crust of silica which forms a floor of greater or less thickness for the entire valley.

The mountains which form the divide between the sources of the Madison and the Yellowstone are very high and steep. After traveling about 8 miles, we came to the nearly vertical sides of the main divide, which is composed of trachytic basalt. Immense quantities of broken rocks had fallen down at the bottom of the ridges. Little lakes occur every mile or so, nestled among the pines 9,000 and 10,000 feet above the sea. At the head of Fire-Hole we ascended a steep ridge, with almost vertical sides, with just room to travel, to the summit of the divide.

Fig. 62.



OLD FAITHFUL, UPPER GEYSER BASIN, FIRE-HOLE RIVER.

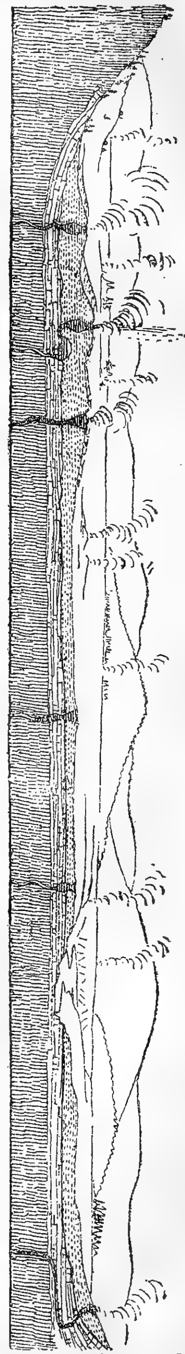
From this point we could look back and obtain a full view of the Madison Valley with its branches, and the high volcanic mountains that inclose it. The mountains are gashed with deep gorges, and on the sides are immense quantities of the fragments of trachyte and obsidian. The pines grow upon the declivities of the mountains where they are so steep that it would be impossible for a man ever to ascend. The elevation of what appeared to be the highest point of our route was 9,500 feet, but the general elevation of the mountain summits is about 10,000 feet. It is only in exceptional cases that isolated peaks rise above that elevation.

As we descended the mountains on the east side, we saw through the

trees what we thought at first was one of the arms of the Yellowstone Lake. It proved to be Lake Madison, a most beautiful sheet of water, set like a gem among the mountains, with the dense pine forests extending down to the very shores. A ridge or promontory extends into the lake on the west side for about half a mile, which gives it a heart-shaped form. It is about three miles from north to south, and two from east to west. The shores of the lake are paved with masses of trachyte and obsidian.

Leaving Madison Lake, we crossed a second high basaltic ridge, and descended into the drainage of the Yellowstone. Dense pine forests, with here and there open grassy glades, deep gullies which seemed to have no water except during the melting of the snows in spring, occur everywhere. Old hot-spring deposits occur here and there, covering limited areas. We camped at night on the shore of a lake which seemed to have no outlet. It is simply a depression which receives the drainage of the surrounding hills. It is marshy around the shores, and the surface is covered thickly with the leaves and flowers of a large yellow lily. The water is not clear and cold like that of the other mountain lakes, but more like rainwater. The vegetation was very luxuriant all over these lowlands, and the flowers were abundant and varied. The lake was about two miles long and one wide, and it is doubtful whether it had ever been observed by human beings before.

The following morning we reached our camp at the hot springs, on the southwest arm of the Yellowstone Lake.



IDEAL SECTION, UPPER GEYSER BASIN, FIRE-HOLE RIVER.

Fig. 63.

NOTES TO CHAPTER VI.

As an appendix to this chapter, I quote a few paragraphs from a remarkably interesting though scarce volume, entitled "New Zealand: its Physical Geography, Geology, and Natural History," by Dr. Ferdinand von Hochstetter. The hot springs and geysers of New Zealand are so similar to those in the Yellowstone Basin, and scarcely less inferior in interest, that I gladly call attention to this most interesting and instructive work. The origin of these hot springs is undoubtedly the same all over the world. Those in Iceland have been studied by the ablest scientific men from all portions of the world.

The second extract is from a very able work by Professor Gustave Bischof, "Researches into the Internal Heat of the Globe," (page 225.) These extracts will serve to convey the opinions of eminent scientific men who have made the subject of hot springs a special study.

EXTRACT FROM HOCHSTETTER'S "NEW ZEALAND."

"Both kinds of springs owe their origin to the water permeating the surface and sinking through fissures into the bowels of the earth, where it becomes heated by the still existing volcanic fires. High-pressure steam is thus generated, which, accompanied by volcanic gases, such as muriatic acid, sulphurous acid, sulphureted hydrogen, and carbonic acid, rises again toward the colder surface, and is there condensed into hot water. The over-heated steam, however, and the gases decompose the rock beneath, dissolve certain ingredients, and deposit them on the surface. According to Bunsen's ingenious observations, a chronological succession takes place in the co-operation of the gases. The sulphurous acid acts first. It must be generated there where rising sulphur vapor comes into contact with glowing masses of rock. Wherever vapors of sulphurous acid are constantly formed, there acid springs, or solfataras, arise. Incrustations of alum are very common in such places, arising from the action of sulphuric acid on the alumina and alkali of the lavas; another product of the decomposition of the lavas is gypsum, or sulphate of lime, the residuum being a more or less ferruginous fumarole clay, the material of the mud-pools. To the sulphurous acid comes sulphureted hydrogen, produced by the action of steam upon sulphides, and by the mutual decomposition of the sulphureted hydrogen and sulphurous acid, sulphur is formed, which in all solfataras forms the characteristic precipitate, while the decomposition of siliceous incrustations is either entirely wanting or quite inconsiderable, and a smell of sulphureted hydrogen is but rarely noticed. These acid springs have no periodical outbursts of water.

"In course of time, however, the source of sulphurous acid becomes exhausted, and sulphureted hydrogen alone remains active. The acid reaction of the soil disappears, yielding to an alkaline reaction by the formation of sulphides. At the same time, the action of carbonic acid begins upon the rocks, and the alkaline bicarbonates thus produced dissolve the silica, which, on the evaporation of the water, deposits in the form of opal, or quartz, or siliceous earth, and thus the shell of the springs is formed, upon the structure of which the periodicity of the outbursts depends. Professor Bunsen, rejecting the antiquated theory of Makenzie, based upon the existence of subterraneous chambers, from which the water, from time to time, is pressed up through the vapors accumulating on its surface, according to the principle of the Hern fountain, has proved in the case of the great geyser that the periodical eruptions or explosions essentially depend upon the existence of a frame of siliceous deposits, with a deep, flue-shaped tube, and upon the sudden development of larger masses of steam from the overheated water in the lower portions of the tube. The deposition of silica in quantities sufficient for the formation of this spring apparatus in the course of years takes place only in the alkaline springs. Their water is either entirely neutral or has a slightly alkaline reaction. Silica, chloride of sodium, carbonates, and sulphates are the chief ingredients dissolved in it. In the place of sulphurous acid the odor of sulphureted hydrogen is sometimes observed in these springs.

"The rocks, from which the siliceous hot-springs of New Zealand derive their silica, are rhyolites, and rhyolithic tufas, containing seventy and more per cent. of silica; while we know that in Iceland palagonite, and palagonitic tufas, with fifty per cent. of silica, are considered as the material acted upon and lixiviated by the hot water. By the gradual cooling of the volcanic rocks under the surface of the earth in the course of cen-

turies the hot springs also will gradually disappear; for they too are but a transient phenomenon in the eternal change of everything created."—(Hochstetter's New Zealand, English translation, p. 432.)

EXTRACT FROM BISCHOF'S "RESEARCHES INTO THE INTERNAL HEAT OF THE GLOBE."

"No doubt can be entertained respecting the nature of the agent by which the waters of the geyser, the Strokr, and other less considerable springs, are thrown to such an immense height. It is, as in volcanoes, a gaseous body, principally aqueous vapor. We may, therefore, very fairly agree with Krug Von Nidda, and consider volcanoes in the same light as intermittent springs, with this difference only, that instead of water, they throw out melted matters.

"He takes it for granted that these hot springs derive their temperature from aqueous vapors rising from below. When these vapors are able to rise freely in a continual column, the water at the different depths must have a constant temperature, equal to that at which water would boil under the pressure existing at the respective depths; hence the constant ebullition of the permanent springs and their boiling heat. If, on the other hand, the vapors be prevented by the complicated windings of its channels from rising to the surface; if, for example, they be arrested in caverns, the temperature in the upper layers of water must necessarily become reduced, because a large quantity of it is lost by evaporation at the surface, which cannot be replaced from below. And any circulation of the layers of water at different temperatures, by reason of their unequal specific gravities, seems to be very much interrupted by the narrowness and sinuosity of the passage. The intermitting springs of Iceland are probably caused by the existence of caverns, in which the vapor is retained by the pressure of the column of water in the channel which leads to the surface. Here this vapor collects, and presses the water in the cavern downward until its elastic force becomes sufficiently great to effect a passage through the column of water which confines it. The violent escape of the vapor causes the thunder-like subterranean sound and the trembling of the earth which precedes each eruption. The vapors do not appear at the surface till they have heated the water to their own temperature. When so much vapor has escaped that the expansive force of that which remains has become less than the pressure of the confining column of water, tranquillity is restored, and this lasts until such a quantity of vapor is again collected as to produce a fresh eruption. The spouting of the spring is therefore repeated at intervals, depending upon the capacity of the cavern, the height of the column of water, and the heat generated below."

The various groups of mud-springs, or salses, which are described in the preceding chapter are scarcely less interesting and instructive than the geysers. The following analyses of the sediment, by Professor Augustus Steitz, of Montana, for Mr. Langford, will be useful for comparison. The reader is also referred to the report of Dr. A. C. Peale in this volume. I have appended a few analyses of the hot-spring deposits from New Zealand, from the interesting work of Dr. Hochstetter.

Analyses of mud or sediment from mud-springs.

White sediment.		*Lavender sediment.*		*Pink sediment.*	
Silica	42.2	Silica	28.2	Silica	32.6
Magnesia	33.4	Alumina	58.6	Alumina	52.4
Lime	17.8	Boracic acid	3.2	Oxide of calcium	8.3
Alkalies	6.6	Oxide of iron	0.6	Soda and potassa	4.2
		Oxide of calcium	4.2	Water and loss	2.5
		Water and loss	5.2		
	100.0		100.0		100.0

Siliceous deposits of hot springs, on the shores of the Rotomahana, New Zealand, analyzed by Mr. Mayer.

[No. 1, Tetarata, two samples, *a*, an earthy, powdery mass; *b*, solidified incrustation; No. 2, Nagahapu; No. 3, Whatapoho; No. 4, Otukapuarangi.]

	1.		2.	3.	4.
	a.	*b.*			
Silica	86.03	84.78	79.34	88.02	86.80
Water and organic substances	11.52	12.86	14.50	7.99	11.61
Sesquioxide of iron	1.21	1.27	1.34	2.99	Slight indication.
Alumina			3.87		
Lime	0.45	1.09	0.27	0.64	Slight indication.
Magnesia	0.40		0.26		
Alkalies	0.38		0.42	0.40	

I, Pattison (Philos. Magazine, 1844, p. 495) and, II, Mallet (Philos. Magazine 1, 853, p. 285) give the following analyses of the siliceous deposits on the hot springs of Lake Taupo, without, however, specifying the localities:

	I.	II.
Silica	77.35	94.20
Alumina	9.70	1.58
Sesquioxide of iron	3.72	0.17
Lime	1.54	Indication.
Chloride of sodium	....	0.85
Water	7.66	3.06
	99.97	99.86
Specific gravity	1.968	2.031

CHAPTER VII.

FROM HOT SPRING CAMP, ON YELLOWSTONE LAKE, UP PELICAN CREEK AND DOWN EAST FORK, TO BOTTLER'S RANCH.

We were joined at our Hot Spring camp by Lieutenant G. C. Doane, who had visited this region the previous year in company with Messrs. Washburn and Langford. Captain Tyler and Lieutenant Grugan had been ordered to return, with most of the escort, to Fort Ellis, and they were already on their way to the post by way of the Madison Valley. We remained here for a day or two, studying the hot springs and resting our animals. From this point Messrs. Elliott and Carrington commenced the survey of the shore-line of the lake with our useful little bark, the Anna. They were absent seven days, and during the time sailed around the entire shore-line, about one hundred and seventy-five

miles, sketching every bay or indentation, as well as the mountains that inclose it. The topographical survey was continued around the south and west shores of the lake with perfect success. A series of careful observations for elevations were taken at all our permanent camps, as well as at other suitable localities; so that the height of the lake above the sea may be regarded as very accurately attained.

A small party in charge of Mr. Stevenson returned from Hot Spring camp to Bottler's Ranch, by way of the west side of the lake, to obtain additional supplies. On the evening of August 9, we camped at the head of the main bay, west of Flat Mountain. Our hunters returned, after diligent search for two and a half days, with only a black-tailed deer, which, though poor, was a most important addition to our larder. It seems that during the months of August and September the elk and deer resort to the summits of the mountains, to escape from the swarms of flies in the lowlands about the lake. Tracks of game could be seen everywhere, but none of the animals themselves were to be found. Our course around the lake was intended to follow the shore as far as possible. We made our way among the dense pines or over the fallen timber, sometimes in grassy glades, through marshes, or by lily-covered lakes. The little streams, which are at this season mostly dry, have worn deep gullies through the superficial beds, showing the old lake deposits to have been from 200 to 600 feet in thickness.

At sunrise on the morning of August 10, at the west base of Flat Mountain, the thermometer stood at $15\frac{1}{2}^{\circ}$, and water was frozen in my tent one-fourth of an inch thick. The rocks of Red Mountain are trachyte, with a purplish tinge, quite hard, and somewhat spotted and banded. Some portions of the mountain are very red, and from this fact it derives its name. Those of Flat Mountain are the same in texture and color. From the summit of Flat Mountain we had an excellent view of the lake. Three islands were visible, one of them quite small, 200 yards long, covered with pine timber. It is really an elevated ridge of sand. The other two are about a mile in length, also covered with a dense growth of pines. Along the shores of these islands are bluff banks of stratified volcanic sand, 50 feet high. All these islands are probably elevated portions of the old lake-bed, which have gradually risen above the surface as the waters of the present lake diminish. To the westward a still higher range can be seen, and near it Heart Lake, and still further west Madison Lake, embosomed among the mountains. On the long points or fingers, as it were, that extend out into the lake, are several small lily-ponds, and open meadow-spaces, covered with thick grass. The general view, however, consists of an outer range or rim of volcanic peaks, from 10,000 to 11,000 feet high, with the inner portions, or belt of lower hills and ridges, black with the dense forests of pine, but relieved here and there by a small lake, or an open meadow glade. The altitude of Flat Mountain is 9,704 feet.

From this high point, with the grand basin spread out before us, we may again ask a question in regard to its origin. On all sides, and among the foot-hills, the *débris*, which consist of fragments of trachyte, are enormous. Steps produced by slides can be seen most clearly by looking over the dark mass of pines. We still believe that the basin was at first a depression, produced by the action of the volcanic forces which built up the surrounding groups of mountain peaks, and formed a reservoir for their drainage, but that it is also due in part to erosion. A vast amount of material has been ground up by the waters of the lake from the sides of the basin, to form the extensive modern deposit which we meet with everywhere.

Leaving our camp at Flat Mountain, we ascended the high hills, among the fallen timber, taking a course about southeast, passed over the divide, and at night found ourselves on the head-waters of Snake River. The rocks, as usual, were trachytic basalt, for the most part; but in ascending the divide from the Yellowstone Lake, we find Carboniferous limestones, with the accompanying clays, in one locality. Examples of the exfoliation of the igneous rocks are very common.

Between Flat Mountain and the Yellowstone Range the divide is very low. The sources of some of the branches of Snake River extend up within two miles of the lake, and the elevation is not more than 400 feet above the lake level. This is what has been hitherto understood as "Two Ocean Pass." The separation of the drainage between the Yellowstone Basin and Snake River is complete. The valley of Snake River is very pleasantly diversified with meadow-like openings and dense forests of pines. Some of these glades are two to four miles long and one to two miles wide. This transition from forest to meadow continues all along the river and its branches, from their sources to the junction with the Columbia.

From our camp on Snake River, we traveled north of east to the shores of the lake. The broad lowlands are most pleasantly diversified with groves of pines and fine grassy meadows, and numbers of streams, some of which were of considerable size, flowed from the mountains into the lake. One of these creeks was 75 feet wide and 2 feet deep. All the rocks we met with were basalt and basaltic breccia. The Yellowstone Range, so far as I could examine it, was composed of breccia, though it undoubtedly contains a nucleus of trachyte; for the masses of it, which could not have been transported far, were scattered over the surface. We crossed the marshy valley of the Upper Yellowstone, which is about three miles wide, and pitched our tents upon a sort of terrace on the east side of the southeast arm, 80 feet above the water-level of the lake. From this point we made a small side trip to the source of the Upper Yellowstone, and thence to the sources of the Snake River. The entire region is one of great interest. On the morning of August 12, I started up the valley of the Upper Yellowstone, accompanied by Messrs. Doane and Schonborn, for the purpose of making a careful geological as well as topographical survey of the district bordering the great divide. Five streams of water flow into the Upper Yellowstone from the mountains on either side of the head of the valley, and at this season of the year the vegetation is fresh, green, and most abundant. It would be difficult to find a valley in the West that presents as fine a picture to the eye. On either side, the valley, which is about three miles wide, is walled in by dark, somber rocks of volcanic origin, which have been weathered into remarkable architectural forms. Looking up the valley from some high point, one could almost imagine that he was in the presence of the ruins of some gigantic city, so much like old castles, cathedrals of every age and clime, do these rocks appear; add to this, the singular vertical furrows which are cut deep into the sides and render more striking their antiquated appearance. At the base of the wall-like ridges of the valley, immense masses of volcanic breccia have fallen down from the mountain-tops, in many instances crushing down the pines along their path. About fifteen miles above the lake the valley terminates abruptly, the mountains rising like walls, and shutting off the country beyond. The river here separates into three main branches, with here and there smaller ones, which bring the aggregated waters of the melted snows from the summits of their bare volcanic peaks. Just at the head of the valley there is a little lake, but not more than one or two hundred yards in width.

The lake which has been placed on the maps as Bridger's Lake has no real existence.

From the head of the main valley we ascended the mountains on the west side, and from the summit of a high peak the whole basin with the divide was brought within the scope of our vision. As far as the eye could reach on every side, bare, bald peaks, domes, ridges in great numbers could be seen. At least one hundred peaks, worthy of a name, could be located within the radius of our vision. The rocks everywhere, though massive, black, and deeply furrowed vertically, have the appearance of horizontal stratification. In some instances the furrows are so regular that the breccia has a columnar appearance. The summits of the mountains are entirely composed of breccia. Angular masses of trachyte, 10 to 30 feet in diameter, are inclosed in the volcanic cement. Most of the fragments are small, varying from an inch to several feet, seldom much worn. We camped at night near a small lake, by the side of a bank of snow, 10,000 feet above the sea, with the short spring grass and flowers all around us. There are but two seasons on these mountain summits, spring and winter. In August the fresh new grass may be seen springing up where a huge bank of snow has disappeared. The little spring-flowers, seldom more than one or two inches high, cover the ground; *Clatonia*, *Viola*, *Ranunculus*, and many others. The following morning we traveled for several miles along a ridge not more than two hundred yards wide, from one side of which the waters flowed into the Pacific, and on the other, into the Atlantic. To the westward the outlines of the Teton Range, with its saw-like or shark-teeth summits, were most clearly visible. They seemed to be covered with an unusual quantity of snow. From whatever point of view one can see the Teton Range, the sharp-pointed peaks have the form of huge sharks' teeth. To the southward, for fifty miles at least, nothing but igneous rocks can be seen. Toward the Tetons there is a series of high ridges, of which the Teton Range seemed to be the central one. These ridges, which pass off from the main Teton Range, incline to the northeast, and vary in height from 9,500 to 10,500 feet above the sea-level, and 1,000 to 1,800 feet above the valleys at their base.

We ascended one of the high ridges, (not the highest, however,) and found it to be 1,650 feet above the valley at its foot. The northeast side is like a steep roof, while the southwest side breaks off abruptly. From the summit of the ridge, the view is grand in the extreme. To the westward the entire country, for the distance of fifty miles, seems to have been thrown up into high, sharp ridges, with gorges 1,000 to 1,500 feet in depth. Beautiful lakes, grassy meadows also, come within the vision. I can conceive of no more wonderful and attractive region for the explorer. It would not be difficult for the traveler to make his way among these grand gorges, penetrating every valley, and ascending every mountain or ridge. The best of grass, wood, water, and game are abundant to supply the wants of himself or animals.

I think that numerous passes could be found from the valley of Snake River to the basin of the Yellowstone. It seems to me there are many points on the south rim of the basin where a road could be made with ease into the valley of Snake River. From this ridge it would seem that there could be but little difference in the altitude of the Yellowstone Lake and Heart Lake, and they cannot be more than eight or ten miles apart, and yet the latter is one of the sources of Snake River. The little branches of Snake River nearly interlace with some streams that flow into the lake, and the gullies come up within two miles of the shore-line.

There is a very narrow dividing ridge in one place, between the drainage, which may be within one mile of the lake.

As we have stated in the previous pages of this report, the rocks of this basin are mostly volcanic, but on the south side of the divide, between the Yellowstone and the sources of the Snake, the series of ridges extending southward to the Tetons are largely sedimentary. Carboniferous limestones occupy restricted areas, while some of the highest ridges are made up of Cretaceous and Tertiary strata. One ridge, the summit of which was over 10,000 feet above the sea, and overlooks the country for fifty miles in every direction, is the exact dividing ridge which separates the drainage of the two basins. On the summit and north side of the ridge the rocks were smooth, as if vast masses of snow and ice had slidden down for ages. The rocks are composed of somber-brown and rusty grayish-brown sandstones, in which I found great quantities of leaves of deciduous trees. There was one fern and a palm of huge dimensions. From these exposures of the sedimentary beds, I draw the same conclusion that I have done so many times previously, that the unchanged rocks either now exist or have existed all over the Northwest; that they may have been removed by erosion, concealed by overflows of igneous material, or thrown up into ridges; but the one final conclusion is, that they extended all over the region about the sources of these great rivers, in a horizontal position, at a comparatively recent geological period.

On our return to the east side of the lake from the sources of Snake River, we followed down the valley of a little stream that has its origin at the foot of the ridge. As it flowed toward the lake, it cut a deep channel into the lake deposits, sometimes 50 to 100 feet, well illustrating the character of the materials. It was composed at the bottom of grayish-white clays, passing up into a sort of bowlder deposit, all derived from the degradation of volcanic rocks.

We may here discuss for a moment, in general terms, the geological character of the mountains on the east side of the lake. The Upper Yellowstone River rises in the high volcanic range which shuts off the Yellowstone Basin from the Wind River drainage, forming what is usually called the great water-shed of the continent. The range of mountains on the east and south sides of the Yellowstone Basin gives origin to the waters of the Snake River, which flow west into the Pacific, to those of Green River, which flow southward into the Great Colorado, and to the numerous branches of the Yellowstone. Upon the east and southeast sides, the mountains seem to be entirely of volcanic origin; they are also among the ruggedest and most inaccessible ranges on the continent. From the valley of Wind River they present a nearly vertical wall from 1,500 to 2,000 feet high, which has never been scaled by white man or Indian; but are covered with perpetual snows to a greater or less extent. From any high point a chaotic mass of peaks of every variety of form may be seen extending from the Snake River Valley to the lower cañon of the Yellowstone. The general level of the summits is about 10,000 feet, but some of the higher peaks reach 10,500 to 11,000 feet. Many of them are the nuclei of old volcanic cones, composed of very compact trachyte; others are portions of the rim of a vast crater. Mounts Doane and Stevenson are fragments of the rim of an immense crater, the layers of trachyte inclining from the basin on every side; some of the centers of effusion were long fissures, forming ridges. All around these nuclei, and sometimes reaching nearly to the summits, are the volcanic conglomerates or breccias in horizontal strata. Even the highest portions of the mountains, the broad ridges that form the very water-shed, are composed of these

breccias, and it is quite possible that they even conceal the great mass of compact trachyte rocks. At any rate, so far as the eye can reach, the true trachyte rocks are exposed only in the form of cones, here and there, while the great mass on the surface is the breccia. They are continually disintegrating, so that all over the sides of the mountains and among the foot-hills there are immense quantities of *debris;* not unfrequently huge masses are gradually broken off from the sides of the mountains by the combined action of water and ice, leaving a vertical wall 50 to 200 feet or more in height.

From our camp on the east side of the lake, we ascended Mounts Doane and Stevenson. Between the lake shore and the summits of these peaks, there is a succession of ridges, which measured 8,500, 8,800, 9,000, 9,200, 9,400 feet, &c. These peaks, with an intermediate lower portion, form a part of the rim of a huge crater, and on the inner side the layers of trachyte appear like strata, inclining from the crater 10°. The rocks are somewhat varied in texture, more or less compact, but mostly very compact hornblende trachyte. Near the summit the rocks are slightly porous, true basalt, as if they had not been subjected to much pressure. Some of the rocks are red or ashen-gray, and have a slaty cleavage; the volcanic breccia rises to the height of 2,000 to 2,500 feet above the lake.

On the east side, the proofs of the former elevation of the lake may be seen 300 to 500 feet high on the sides of the mountains. The little streams that cut through the lower hills, along the borders of the lake, expose 150 to 200 feet of stratified, recent deposits. Near Steam Point the waters of the lake have washed the shores for two or three miles, so as to expose 100 to 150 feet of strata, composed of volcanic sand and gravel at the bottom, passing up into fine sand, and at the top considerable thickness of coarse sandstone and conglomerates. All these modern deposits have been permeated and in part cemented with, the silica of the old hot springs. We have said enough about the modern lake deposits to establish the fact that they are worthy of attention, and form a portion of the geological history of this basin. We shall only allude to them hereafter as we meet them in our travels.

One of the most remarkable localities for extinct springs is on the east side of the southeast arm of the lake, at the head of Alum Creek, and marked on the map "Brimstone Basin." For half a mile before reaching this spot the air is filled with a disagreeable sulphurous smell. The deposit is mostly silica, though there is a good deal of sulphur mingled with it. In the bed of the little stream that passes through the basin are numerous small springs, from which bubbles of gas are constantly escaping, probably sulphureted hydrogen. The little creek which passes through the basin rises in the higher ridges ten miles distant, and, as it passes through the spring deposit, is rendered turbid like milk. The channel is coated with a creamy-white material, silica and sulphur; old pine logs, which must once have formed large trees, now lie prostrate in every direction over the basin. It covers an area of about three miles in extent, and, in some instances, a vertical thickness of 50 feet was exposed. Not a trace of any spring could be found with a temperature above ordinary spring-water. From all appearances, this basin must have been active within a comparatively modern period. It is true, however, that these springs are continually becoming extinct, and have done so ever since the great period of volcanic activity in this region.

The hot-spring district, above and below Steam Point, is quite interesting, as showing the remains of what was once a very important group.

The hot-spring area extends about five miles along the lake shore, and is about two miles wide. Steam Point has been, at one time, covered with very active springs, but now they are fast becoming extinct. Two steam-vents are now in operation, sending forth steam with a noise like that of the escape-pipe of a steamboat. A number of small simmering springs are scattered around these vents. There is here a thickness of 200 feet of conglomerate, which is made up largely of hot-spring deposits. The lake seems to have beaten against the shore, and worn away a large portion, leaving a bluff wall 50 feet high above water-level. A large mass of the conglomerate has been cut off by the waves, and left in the lake 100 feet from the bluff shore. South of Steam Point, on the shore of the lake, are about twenty or thirty springs of various temperatures, from 110° to 192°. Some are quiet, some bubbling quite briskly, and others are true boiling springs. The little steam-vents are lined with sulphur. About a mile east of the point, around a little lake, there is an extensive group of springs. The ground is covered with sulphur, alum, common salt, &c., tinged with oxide of iron. Thick deposits of silica, often tinged with oxide of iron or sulphur, attest the former existence of a much larger system of springs than we find here at the present time. At one point, in the bed of the little creek that flows into the small lake, which is 10 feet wide and 2 feet deep, there is a large spring that boils up very fiercely, and yet the temperature is not above that of the water of the creek itself. The agitation of the water must be due to the escape of gas alone. At Steamboat Point, and around the little lake, the ground is in places perforated, like a cullender, with the little simmering vents, which denote, I think, the last stages of a system of larger springs.

Proceeding southward along the shore of the lake, we meet with the springs and steam-vents, in greater or less numbers, scattered along the shore—186°, 183°, 185°, 178° will, perhaps, give the average temperatures—all quiet, bubbling, or boiling springs. Sulphur Hills, on the north side of the lake, is another of the magnificent ruins, of which only a few steam-vents now remain. The deposit, however, is a large one, and covers the side of the mountain for an elevation of 600 feet along the lake shore, the huge white mass of silica covering an area of about half a mile square, and can be seen from any position on the lake shore, and appears in the distance like a huge bank of snow. In the valley near Pelican Creek, a few springs are issuing from beneath the crust, distributing their waters over the bottom, and depositing the oxide of iron, sulphur, and silica, forming the most beautiful blending of gay colors. Although the waters of the springs are 160°, yet the channels are lined with a thick growth of mosses and other plants, and in the water is an abundance of vividly green algous vegetation. The great mass of hot-spring material built up here cannot be less than 400 feet in thickness. A large portion of it is pudding-stone and conglomerate. Some of the rounded masses inclosed in the fine white siliceous cement are themselves pure white silica, and are eight inches in diameter. It is plain, from the evidence still remaining, that this old ruin has been the theater of tremendous geyser action at some period not very remote; that the steam-vents, which are very numerous, are only the dying stages. These vents or chimneys are most richly adorned with brilliant yellow sulphur, sometimes a hard amorphous coating, and sometimes in delicate crystals that vanish like frost-work at the touch. It seems that it is during the last stages of these springs that they adorn themselves with their brilliant and vivid colors.

We will now bid farewell to this remarkable lake-basin, and, taking a

northeasterly course, pass up the valley of Pelican Creek, and cross the mountains to the east branch of the Yellowstone. We have endeavored to explore the great basin with all the care that our time and facilities would permit. Much has been left undone, but we feel certain that we have obtained information enough to convince our readers that the region we have examined is invested with profound interest. We have explored, with much care and detail, one of the most beautiful lakes in the known world. Our soundings, which are expressed on the chart in fathoms, show that its greatest depth is 300 feet. According to a careful series of soundings of Great Salt Lake, Utah, by Mr. Dieffendorf, for the purpose of finding the deepest channels for a steamer, the average depth is only about 12 feet, while the greatest depth was found to be only 60 feet, and that was between Antelope Island and Stansbury Island.

We traveled up the valley of Pelican Creek about eighteen miles. Hot springs were scattered along the bottom, some of them of considerable size and beauty. There were many dead and dying ones, some of which indicated great age; the immediate bottom is incrusted with the silica. The average width of the valley is about two miles, and at this season of the year (August 23) the grass and other vegetation is very fresh and abundant. If it were not for the elevation and climate, this valley would soon be filled with enterprising, thriving ranchmen and farmers. The valley itself is underlaid with the modern lake deposits, which extend up almost to the divide. It is plain, from a system of terraces more or less distinct, that the lake once extended high up the valley, and that the fertility of the soil and the present exuberance of vegetation are due to this fact. The broken range of hills and mountains that inclose it on either side are covered with forests of pine, and the rocks are entirely of volcanic origin—the trachytes and conglomerate. Ten miles up the creek is a pretty little cascade, where the waters pour over a descent of 15 feet, which is formed of stratified sand and clay. Above the cascade there is a wall 60 feet high, composed of Pliocene deposits. From the divide the view is far extended and very fine. The Grand Cañon of the Yellowstone, with its group of hot springs, with the deep side-cañons that lead into it, and the dense forests of pines, and the north rim of the basin, with the bald, black summits of the volcanic peaks projecting above the tree vegetation, all are presented to the eye at a single glance.

We camped at night on the summit of the divide, between the valleys of the East Fork and the main Yellowstone, by the side of a little lake 10,000 feet above the sea. The wonderful group of peaks which extend along the source of the Yellowstone, and the branches of the Big Horn, from the lake itself to the lower cañon, which constitute on the map, the Heart and Snow Ranges, were in full view, with all their rugged grandeur. The basaltic cones and broken rims of huge craters were clearly visible, while the equally lofty but more rounded, dome-like, conglomerate peaks could be easily detected by their style of weathering. Deep, almost vertical gorges, led down into the valley of the East Fork on the east side of us, and on the west into the main Yellowstone. Here and there a white patch on the mountain-side or in a valley, looking like a bank of snow, showed the former existence of a group of springs.

We descended to the valley of the East Fork, and camped the night of August 24 at the junction of the two main branches. Here we spent one day exploring the east branch of the East Fork, which has its sources high up among the most rugged and almost inaccessible portions of the basaltic range. There are several wonderfully jagged peaks about the sources of this branch, which rise up 10,000 to 11,000 feet above the sea.

I ascended one of the highest, though not the highest, and found it 10,950 feet. The general average of these peaks is about 10,000 feet. The summits of these high peaks are all close, compact trachyte, while all around the sides are built up walls of stratified conglomerate. It is plain that all of them are the nuclei of old volcanoes. The trachyte may sometimes be concealed by the conglomerates, but I am inclined to think that each one has formed a center of effusion. Large quantities of silicified wood are found among the conglomerates, mostly inclosed in the volcanic cement, evidently thrown out of the active craters with the fragments of basalt. My impression is, that when the old volcanoes disgorged their contents into the great lake of waters around, they threw out also portions from the sedimentary formations, and thus the silicified wood comes from the Tertiary or Cretaceous beds, which may have formed the upper part of the walls of the crater. At any rate, these woods belong to the Coal Series of the West, and they are scattered profusely among the conglomerates. Interlaced among the massive beds of volcanic conglomerates, are some layers of a light-gray or whitish, sandy clay, which show that the whole breccia or conglomerates, with the intercalated layers of clay or sand, were deposited in water like any sedimentary water rocks.

Upon the east branch are a few interesting ruins of springs. There is one very curious mammiform mound, about forty feet high, built up by overlapping layers, like the "Cap of Liberty" on Gardiner's River, only by much less hydrostatic force. The material is principally calcareous. This cone is a complete ruin. No water issues from it at the present time, and none of the springs in the vicinity are above the ordinary temperature of brook-water; sulphur, alum, and other chemical deposits are abundant. This old ruin is a fine example of the tendency of the cone to close up its summit in its dying stages. The top of the cone is somewhat broken; but it is 18 feet in diameter at this time, and near the center there is a hole or chimney 2 inches in diameter, plainly a steam-vent. This marks the closing history of this spring. The inner portions of this small chimney are lined with white enamel, thickly coated with sulphur, which gives it a sulphur-yellow hue. The base upon which the cone rests varies in thickness. On the east side huge masses have been broken off, exposing a vertical wall 20 feet high, built up of thin horizontal laminæ of limestone. On the west side the wall is not quite as high, perhaps eight or ten feet. It would seem, therefore, that it was at first an overflowing spring, depositing thin horizontal layers, until it built up a broad base ten to twenty feet in height; then it gradually became a spouting spring, building up with overlapping layers like the thatch on a house, until it closed itself at the top and ceased.

We may inquire again in regard to the origin of the lime in this cone. Not over a mile below the spring, the Carboniferous limestone comes to the surface, and as we follow the river down toward its juncture with the main Yellowstone, it soon becomes 400 feet in thickness; hence we know that these limestones extend under the valley of this east branch, and that the waters passed up through them, and thus we have a predominance of lime instead of silica, as is the case at Gardiner's River. Over this limestone the basaltic rocks have been poured, rising to the height of 2,000 or 2,500 feet above the valley. Immense quantities of the broken fragments of basalt have fallen down on the sides of the mountains, and, by their bright black color, look like heaps of anthracite coal in the distance. About five miles below the junction of the two branches of the East Fork, the mountains on the east side become quite rounded and grass-covered, instead of the bald, black, rugged character

of those near the sources of the river. The granite rocks begin to prevail, and the mountains have an older appearance. The valley is full of immense, rounded, granite bowlders, which have been swept down from the mountains by aqueous forces not now in existence. There are also in this valley well-defined terraces 30 to 50 feet high, and above the forks are rows of basaltic columns like those in the lower portion of the Grand Cañon. At the mouth of Hell-Roaring River the granitoid rocks are displayed on a grand scale. As I have previously stated, the basis rocks of the mountains are granite or gneissic granites; sometimes they are true granites, as exposed about the junction of the East Fork and main branch of the Yellowstone, and at Hell-Roaring Mountain; even these, perhaps, come under the head of stratified metamorphic rocks, from the fact that above and below these thick, massive granites are groups of gneissic strata of various textures. On the east fork I saw only the Carboniferous limestones. Although the Jurassic, Cretaceous, and Tertiary formations occur in full force at Gardiner's River, over all has been poured the igneous material, which rapidly increases in mass and importance as we ascend the valley, until, about the sources, it entirely covers all other rocks, and sends its multiform peaks high up among the perpetual snows.

The bridge which has been constructed across the Yellowstone, near the forks, was designed to accommodate the miners on their way to the gold-mines on Clark's Fork, and is the first and only bridge ever built on the Yellowstone. It may become a matter of some historical importance to note this fact here. The gold-mines are all in the granitoid rocks, and, from what I can learn, all the streams that flow into the Yellowstone from the east side of the range cut deep down into the metamorphic group. The mines are reported to be excellent, and I am inclined to the belief that the most important mining districts of the Yellowstone drainage will be found eventually on the eastern slope of the Heart and Snowy Ranges.

CHAPTER VIII.

FORT ELLIS—THREE FORKS—JEFFERSON FORK—BEAVER HEAD CAÑON—MEDICINE LODGE CREEK.

In this and the following chapter, I will endeavor to present a brief summary of the geological features of the country along our homeward journey, from Fort Ellis to Evanston, on the Union Pacific Railroad. In a former chapter I have alluded to the range of mountains which extends along the east side of the Gallatin Fork. I also spoke of the Pliocene or lake deposits which jutted up against the base of these mountains, sometimes reaching a thickness of 600 or 800 feet.

The beautiful valley of the Gallatin was undoubtedly one of the numerous lake basins of the West of which so much has been written in my reports for years past. The Pliocene hills opposite Fort Ellis and Bozeman overlook the valley for a great distance, and at this season of the year (September 6) hundreds of acres of golden grain can be seen. There is a remarkable uniformity in the bright-yellow color of a field of grain in this country, probably due to the uniformity of the climate; the sun shines without interruption for weeks in succession. The mountains are composed mostly of rocks of Carboniferous age. They incline

west and southwest, at a variety of angles, 15° to 80°. East of this ridge the Eocene and Cretaceous formations prevail.

As we descend the Gallatin, below Flathead Pass, a series of dark-brown quartzites, sandstones, and pudding-stones rise up from beneath the limestones. Some of the sandstones are very micaceous, as if they had been formed out of mica slates of the metamorphic series. I estimated the thickness to be 1,000 feet, and I have not observed it anywhere else along the sources of the Missouri. No fossils were observed, and the rocks themselves did not seem to promise any. They may possibly be remnants of the Lower Silurian series, left from erosion prior to the deposition of the Carboniferous; at any rate, they appear very old, even partially metamorphosed. The dip of these beds is variable, 10° to 25° northwest, though some local inclinations are greater, with a trend northeast and southwest. These rocks extend across the Gallatin, and underlie, to some extent, the terraces and Pliocene deposits between the forks. The Gallatin River passes across the edges of this series, showing the uplifted strata on both sides, passing up into massive limestones and reddish sandstones. The lower series exhibits all the usual signs of mud flats and shallow-water deposits in quite a remarkable degree. It may be that the center groups, from the metamophic strata up, are of Carboniferous age.

Near the junction of the Three Forks, the Pliocene beds are well shown, and on both sides of the Madison, for ten miles or more above the junction. The bluffs on either side are high, composed of the light-colored clays, sands, and sandstones of the lake deposits. A careful examination, I have no doubt, would have shown the existence of vertebrate remains. I heard of the discovery of bones, teeth, and turtles by the farmers, but could not secure any.

The Missouri below the Three Forks, passes through a cañon formed of the clays and massive limestones of Carboniferous age. On the south and west side of the Jefferson the dip, which is slight, 5° to 10°, appears to be about northwest. About six miles above the junction the limestones rise up from beneath the lake deposits on the south side of the Jefferson in the ridge which forms the tongue or wedge between the Jefferson and Madison. The dip is north and northwest, 45°. Immediately underneath the limestones are the usual gneissic strata, that contain the gold ores. It is not common for any other beds to be brought to the surface between the well-known Carboniferous and the metamorphic; and so far as the sources of the Missouri and the Rocky Mountain divide, it is not uncommon for large areas to be occupied by no beds newer than the Carboniferous.

In the valleys of the Gallatin, Madison, and Jefferson, we find, on the east side of the Gallatin, a range of Carboniferous limestone mountains rising up 8,000 to 9,500 feet above the level of the sea. On the north and west side of the Jefferson, these limestones form high, nearly vertical walls, but between these walls the lake deposits extend up the valleys and form the tongues or ridges that extend down between, for ten miles or more, and it is only here and there that the older rocks crop out. The lake deposits fill the valleys and lap on to the sides of the hills on either side. The cañon of the Missouri, below the junction of the Three Forks, was evidently the outlet of the lake, that had its deepest portion around the Three Forks, and set high up in the valleys to the mountains at their sources. Ascending the valley of the Jefferson, we passed over the high hills on the east side, to avoid the deep cañon through which the river ran for several miles. Granitic strata cropped out in the valleys or gorges, with now and then a protrusion of trachytic basalt. The

highest ridges were covered with the Carboniferous limestones, which passed down into some massive beds of quartzites before resting on the gneissic granites.

For ten miles from the Upper Willow Creek to the entrance of the Boulder Creek into Jefferson Fork, we have the Carboniferous limestones on our right, or west side; on our left, or east side, basaltic rocks cover the lake deposits. The valley is one to one and one-half miles wide, and presents a grand display of the Pliocene marls and sands. The high mountains, with the symmetrical cones, are also igneous. Between North Boulder and Willow Creeks, a distance of about five miles, the Jefferson Fork flows through one of the deepest limestone cañons I have yet seen. The walls on either side rise from 700 to 1,200 feet, almost vertically. The general dip of all the limestones is northwest, and I estimated their aggregate thickness at 2,000 feet. Masses of chert occur in the limestones, which are filled with fossils, spirifers, corals, and crinoidal fragments. The formations are much confused here, from the fact that the basalts have been effused at a recent period, even since a large portion of the lake deposits were laid down. In the gorges that lead down to the Jefferson, they are exposed, and here and there are spread out over the marls. Now and then the limestones or older rocks crop out from beneath them. Along the little streams that flow into the Jefferson as well as the Jefferson itself, are distinctly marked terraces of the lake deposits. for 50 to 200 feet above the river's bed.

The North Boulder Creek enters the Jefferson from the north, through a synclinal valley. On the west side the beds of limestone incline northwest. The general trend of the synclinal is about northeast and southwest. On the west side of the North Boulder and on the south side of the Jefferson, the Carboniferous limestones prevail almost entirely. There are only a few local outbursts of igneous rocks, and not occupying large areas. Above the cañon the valley of the Jefferson expands to a width of one and one-half miles. The lake deposits are again conspicuous, covering the entire valley and extending up the valleys of the side-streams. About three miles above the mouth of the North Boulder Creek, on the same side of the Jefferson, the ravines cut down into a thick series of strata of sandstones, slates, clays, &c., which incline at a moderate angle. These beds are, I think, local, and indicate volcanic action connected with hot springs during the Pliocene period. The clays and sands are variegated, and thick beds of conglomerate occur. The highest mountains are composed of quartzites and a group of light gray vesicular strata in thin layers, which has somewhat the appearance of igneous rocks. White alkaline efflorescence covers the surface in many places.

I may repeat again that the entire surface seems to have been wrinkled or cramped into vast folds or ridges, with a general trend. nearly north and south, or rather west of north and east of south; that the valleys of the streams are for the most part synclinal depressions. The erosion has been so great that it is quite uncommon for rocks of more modern date than the Carboniferous to be seen. The great valleys, or synclinal depressions, during the latter Tertiary period were the basins of fresh-water lakes, so that we have everywhere the white and yellowish-white sands, marls, clays, sandstones, and pudding-stones of the Pliocene lake deposits passing up into the Quaternary or local drift. It is not uncommon for these modern lake deposits to be swept away, so that we know of their former magnitude only by isolated remnants here and there. During this lake period changes were going on in the surface; the general elevation of the country most probably continued, so

that it is not uncommon to find the Pliocene deposits inclining 5° to 10°.

Subsequent to these depositions, there was a period of intense volcanic activity, in which the basalts were poured out over vast areas. We may take, for example, the valley of the Jefferson, from the entrance of the North Boulder into the Jefferson River to Beaver Head Cañon. On the east side of the Jefferson a range of mountains extends along the valley for thirty miles or more, with the northern portions of the west side covered with a large thickness of Carboniferous limestones, like a steep, flexible roof, the highest conical peaks rising to a height of 2,000 to 2,500 feet above the valley. At intervals of one to three or four miles, these mountains are cleft from summit to base by small streams, forming a gorge or cañon of wonderful grandeur and picturesque beauty. The stratified rocks thus reveal a dip varying from 45° to 60°, and apparently pass down, curving under the valley and rising with a reversed dip on the opposite side. The nucleus of all these ranges is, of course, a group of stratified rocks composed of arenaceous clays, slates, quartzites, micaceous gneiss, granulites, &c. A great variety of what I have termed gneissic granites, granitoid rocks, granulites, metamorphic strata, &c., occur. As a general rule, the Carboniferous strata repose unconformably on this group of metamorphic strata; but here and there, a perplexing series of beds come in, quite varied in texture and occupying a restricted area, but revealing no definite evidence of their age. That all the stratified rocks known to exist in the Northwest, to the Lower Tertiary inclusive, once extended all over this region, we have every reason to believe; but about the sources of the Missouri, Yellowstone, and Snake Rivers, the Tertiary, Cretaceous, and Jurassic beds have been swept away, except remnants exposed here and there. The Carboniferous groups, although covering quite large areas, are not unfrequently seen capping the highest mountains that suffered erosion to a tremendous extent. The occurrence of rocks of Triassic age in the northwest is so problematical as yet, that I do not now recognize them. Further investigations may bring to light some evidence that will fix the position of the brick-red beds more positively, and until that time I prefer to include them with the Jurassic.

The metamorphic group contains the valuable mines of Montana. Not unfrequently the most productive gulches are found, where the streams have carved out a gorge through a thick series of Carboniferous limestones, cutting deep into the metamorphic group. The volcanic action seems to have taken place during all the later periods, continuing up to the present time, and operating with greater or less force at different localities. The above may be regarded as a brief summary of the principal points in the geological structure of Montana and Idaho Territories. It remains now to present an account of the local geology from point to point, which must be a repetition substantially of this summary.

The Pliocene deposits extend high up the valleys of the Pipestone and White-Tail Deer Creeks, which are quite wide, with mountains on either side. On the west side of the Jefferson, the foot-hills show a great thickness, 600 to 800 feet. The silicified wood that is found occasionally in these deposits is more beautiful than any I have ever seen from any other formation. It is pure silica, and must have been aided in its silicification by proximity to hot springs. Portions of it look like opal or fine chalcedony, and in some portions the rings of growth are well shown. As cabinet specimens they are especially sought for, and must always be rare. The only other fossils known, are fresh-water and land shells, and a few vertebrate remains. Organic remains of any

kind, will probably never be found in abundance. The mountains on the west side of the Jefferson are lower than those on the east side, a much wider range, and far less rugged in outline. The Carboniferous limestones occur only in restricted patches. The metamorphic group is exposed fully, with here and there an outburst, of the trachyte basalt. All the little streams, as laid down on the map, cut deep channels from the summit to the valley of the Jefferson, and are now or have been filled with miners searching for gold.

The mountains on the west side of Table Mountain and those at the sources of Fish Creek are gneissic and contain valuable mines of gold. The limestone range on the east side of the Jefferson is cut off by the river temporarily, at the bend where White-Tail Deer and Pipestone Creeks enter it; but it commences again on the opposite side and extends far northward. The Jefferson Valley is from five to eight miles wide and of oval shape, narrowing to a cañon at either end. The east range trends about northwest and southeast, while the limestones on the west side dip southwest. They appear to rise vertically out of the valley plain, as if the whole range had either been carried up vertically in a narrow belt, or that it was caused by depression and elevation; that as the range arose the valley was depressed, producing this abrupt flexture in the limestone strata. At Silver Star the metamorphic group comes in close to the Jefferson on the west side, and continues far up for several miles. The strata incline southeast and extend across the mountains and hills in long and quite regular lines. There are here two important gold lodes, "Iron Rod" and "Green Campbell." The latter is seven to ten feet wide, with quartz that pays well. It has been wrought for three years with success.

Just north of "Silver Star" there are some patches of limestone that extend up almost to the summit of the range. This range of mountains lies between Deer Lodge Valley and that of the Jefferson; and although the rocks are mostly metamorphic, yet there are remnants enough of the Carboniferous limestone to show that it formerly extended over the area occupied by the mountains. The elevation of this granitoid range is not as great as the limestone range on the east side. It will average from 800 to 1,500 feet above the valley, some of the peaks reaching 1,000 to 1,500 feet above the bed of the Jefferson. About three miles below the forks of Beaver Head and Big-Hole Rivers, the Stinking Water comes in from the southeast and forms a sort of breach in the limestone range. The latter turns off to the southeast, the limestones cease entirely, and the numerous little branches of the Stinking Water cut deep into the metamorphic strata, forming good mining gulches. On the west side of the Stinking Water the high limestones continue northward to the sources of Stinking Water and Black-Tail Deer Creek, where they were studied by us on our journey to Virginia City in June. The valley of the Stinking Water is from four to six miles in width, and extends up to the cañon, in full view of the Jefferson Valley, so that our two belts of explorations connect from time to time.

Beaver Head Rock is Carboniferous limestone, with a dip 23° southwest. It seems to be a portion of a ridge extending across the valley from the Stinking Water Range. The Beaver Head Fork cuts a narrow channel through it, forming a sort of cañon, with limestone walls on either side. Passing Beaver Head Rock, the strata, which are well shown for miles along the west side of the Beaver Head Fork, seem to incline southwest; and I have no doubt from the style of surface weathering that beds of more modern date, Jurassic or Cretaceous, appear soon on the summits of the mountain hills. Around Bannock City, about twelve or fifteen miles

distant, several outcroppings of coal have been found, which would indicate the presence of Upper Cretaceous or Lower Tertiary beds. Above the Carboniferous limestones, were several layers of sandstone, clays, and quartzites. The sandstones have been used successfully in the manufacture of grindstones. There is no doubt that as we ascend the Rocky Mountain divide, beds of comparatively modern age appear.

The geology of all this region is exceedingly complicated, and must be studied with more care than I could give it, to represent it in colors on a map. This will require a most careful, detailed survey, though the general character of the geology will be found to be as I have presented it in this report. Our journey homeward was so rapid that I could not do more than work out the geological features immediately along the route. The details will be wrought in from year to year, as the great work of exploration goes on.

As we crossed Black-Tail Deer Creek, in ascending the broad, open valley of the Beaver Head, we could look up the valley to the southeast and see distinctly marked on the horizon, thirty miles distant, the limestone range at the sources of the Black-Tail Deer Creek. The valley itself is occupied with a large thickness of the lake deposits, while on the north side the hills are composed of metamorphic rocks, and on the south, far below Wild Cat Cañon, we find the Carboniferous limestones inclining from the sides of the mountains, the nucleus granitic, with extensive outpourings of trachytic basalt.

At Ryan's Station the valley closes up for a time, and the passage of the Beaver Head Fork through the trachyte, forms the well-known Beaver Head Cañon. The igneous rocks are of great variety and texture. Just below the lower entrance of the cañon, on both sides of the river, there is a beautiful, brittle, light-purplish, and whitish porphyritic trachyte or calico rock. Immense masses of unusually perfect breccia, the angular masses set in a white cement, have fallen down on the sides and at the base of the mountains. As we look up the cañon from below, the river seems to rush through a narrow gateway with vertical walls, with dark-purplish basalt weathered into most picturesque forms. From one point of view above the cañon, the rocks on either side present the form of animals couchant, which, in the imagination of the Indian, had a resemblance to the beaver; hence the name which is applied to the river as well as the cañon. Along the cañon in several localities are tepid springs flowing down the sides of the cañon and depositing great quantities of calcareous tufa. About one mile up the cañon, on the west side, there is near the road a high, nearly vertical exposure of 200 feet of soft, yellow and gray limestones, inclining 10° to 25° south of west. In this limestone are layers made up of casts of shells. They are not sufficiently distinct to be identified, but are probably Carboniferous, though the texture of these rocks is different from any I have met with the present season. Rising up from beneath this group of arenaceous limestones are 300 feet of gray sandstones, breaking off vertically in columnar masses, presenting a singularly picturesque appearance. As far up as the mouth of Horse Plain Creek the reddish and gray sandstones and limestones are seen on both sides of the river, with here and there tremendous outbursts of igneous material. The latter sometimes assumes nearly the usual columnar form of basalt, and forms mountains 1,000 to 1,500 feet high above the river, weathered all over the summits into sharp pinnacles. The igneous rocks make fine pictures for the photographer. The river originally flowed along a monoclinal interval, at first separating the sedimentary beds from the metamorphic, but flowing to the northeast, while the trend of the mount-

airs was northwest. It leaves a wide belt of the sedimentary strata on the east side, near Horse Plain Creek. At a point in the cañon, where Clark's Creek enters the Beaver Head from the east side, there is an enormous belt of singular, slaty trachytes, forming high walls on both sides of the road. Immense quantities of *debris*, composed of the fragments of compact basalt, lie on the side and at the base of the hills on either side. At the mouth of Horse Plain Creek the valley expands, the Beaver Head Valley extending up to the southeast, reaching the Rocky Mountain water-shed and Horse Plain Creek Valley trending to the southwest, to the same great divide; both valleys are broad, fertile, and are now occupied by settlers. The elevation is so great that the climate is very severe during the winter. One mile below Beaver Head Cañon the altitude is 4,988 feet; at the junction of Horse Plain Creek and Beaver Head, nine miles above, 5,130 feet. From this point to the main Rocky Mountain divide it is thirty-three miles, and the elevation is 7,405 feet.

Although the soil is fertile, and during the summer season the grass is excellent, yet the altitude about the sources of these streams is too great for successful farming or grazing. About six months of the year the grazing is of superior character, but during the winter months I am of the opinion that stock must be driven down below the cañon for safety. At the junction of Horse Plain Creek with the Beaver Head, a broad valley has been worn out of the uplifted ridges of Carboniferous strata; but just at the junction there is quite a conspicuous remnant of a limestone ridge that escaped erosion, which forms a sort of land-mark. On both sides of Horse Plain Creek, as well as the Beaver Head, the Carboniferous beds are elevated in ridges inclining at various angles. From its source to the junction of Horse Plain Creek, the Beaver Head flows through a synclinal depression, the sedimentary rocks inclining from the Black-tail Deer Range on the east side, while on the west side the same beds incline from a range that extends northward between the Horse Plain and Beaver Head branches. Below the junction of Horse Plain, the Beaver Head flows along a sort of monoclinal interval, while the Horse Plain, which comes in from the west, carves its valley through the ridges nearly at right angles. At one locality, in an anticlinal valley, which runs up northward from Horse Plain Valley, the quartzites and micaceous schists of the metamorphic group rise up beneath the limestones and reddish quartzites of Carboniferous age, over a small area. Thence westward we pass over ridge after ridge of limestones, quartzites, and arenaceous clays to the sources of Horse Plain Creek. Throughout all these valleys, and jutting up against the sides of the mountain hills that inclose them on either side, the Pliocene deposits are always found of greater or less thickness. On the immediate bottoms of the Horse Plain there is an unusual amount of the alkaline efflorescence, or sulphate of soda, covering acres, as white as snow.

As we pass up the valley toward the divide, a great thickness of sandstones and quartzites, at least 1,500 to 2,000 feet, is exposed above the well-known Carboniferous limestones, forming ridges which rise 800 to 1,000 feet above the valleys. The quartzites are so compact and durable that they do not disintegrate, and the hills as well as the valleys are covered with the stray fragments. Here and there a dark, abrupt mass forms the summit of a hill, weathered, perhaps, into sharp pinnacles, indicating a point of effusion of basalt. On a little branch of the Horse Plain Creek, called by the Indians Sage Creek, there are three

quite prominent points of eruption in the range of hills on the east side of the valley.

The mountains on either side are principally Carboniferous and Jurassic, and the valley itself is surrounded with rolling foot-hills, composed of the lake deposits passing up into a great thickness of local drift. On either side the rounded, dome-like peaks rise up 1,000 to 2,000 feet above the valley, which itself is 6,252 feet above the sea. It would be impossible to describe in detail the geological structure of so extended an area of country. Precipitous walls of Carboniferous limestone can be seen on either side; but so chaotic are the positions of the beds in different localities, so obscured by more modern deposits, or the outpouring of basalt, that it can only be by pictorial illustrations that can be presented to the eye that the mind can form a conception of this remarkable region. I shall therefore hasten on, making a few observations from point to point, referring my readers to a more complete and illustrated report hereafter to be prepared for a clearer understanding of my descriptions.

On both sides of Sage Creek, about six miles above its junction with Horse Plain Creek, we find a series of more modern strata. They form the foot-hills of the mountains on each side, extending in some instances nearly to the summits. On the west side they incline from the range about northwest, and on the east side, southeast. Group one, is a series of strata of sandstones and arenaceous clays of various textures, which I supposed to represent No. 1, or Lower Cretaceous; group two, composed of a bed of earthy lignite, passing up into a dark chalky slate, with many fish-scales and some beautiful impressions of ferns and other plants. These shales are nearly vertical, and in some instances dip past a vertical. I regarded these beds as No. 2 Cretaceous, then passing up into yellow chalky beds which might represent No. 3, then upward through clays, sandstones, arenaceous limestones, &c., a thickness of several hundred feet. No shells could be found after a patient search of several hours. The more modern beds, Cretaceous or Tertiary, and possibly both, by more readily yielding to atmospheric agencies, have given a smoother and more rounded form to the mountain hills, and permitted them to be covered with a thick growth of vegetation. Near the head of Sage Creek there is a fine group of mountain peaks, 7,500 to 9,000 feet high. They extend along the divide from Red Rock Creek to Horse Plain Creek, thirty to fifty miles, and may be regarded as remarkable for their symmetrical beauty. At one locality there is an exposure of purplish granulites of the metamorphic group, revealed by the local wearing away of the Carboniferous limestones. As we ascend Sage Creek toward the high divide, we have an occasional exposure of gneiss, enough to show that the nucleus of the mountain ranges is composed of the metamorphic series, with its rocks of varied textures. Here are some purplish granulites, micaceous gneiss, with so large a per cent. of mica that the mass presents a brilliant black color in the distance. Over them are the limestones, sometimes lifted high upon the summits of the mountains, almost horizontal or forming nearly vertical walls on the sides inclosing the narrow valleys. Then come the trachytic basalts of various colors and textures, affecting the adjacent rocks more or less. The quartzites, which are the principal rocks exposed on the immediate divide, have been subjected to the heat of the igneous rocks so that they appear in the distance, dark-brown like compact trachytes.

I may now delay for a moment and make a few general remarks on the geology of the Rocky Mountain divide. We have already

described in as brief terms as we could, the character of the vast area drained by the three forks of the Missouri; we have shown that the mountain ranges lie along the borders of the synclinal valleys, which were originally the basins of fresh-water lakes. All these ranges have a general trend north and south, or northwest and southeast, and yet they are here and there connected by cross-chains, as it were, which give origin to small branches. If we look on the map, (and every map of this country now in existence is very imperfect,) we shall see the three grand streams that constitute the three forks of the Missouri. The main branches flow through valleys which now expand out to a width of three to five miles, then close up in a deep gorge or cañon, then expand out again into broad, fertile, grassy valley so with each from mouth to source. These expansions, or broad valleys, have all been lake-basins during the last portion of the Tertiary period, and perhaps extended into the Drift or Quaternary. On either side, these valleys are inclosed by more or less lofty ranges of mountains, broken here and there by the entrance of some branch, or by some turns in the main river cut through, and another range takes its place. Again, if we look at a correct map we shall see that each one of these main rivers has numerous branches flowing in from either side, and that many of these branches have their small tributaries fed by the snows upon these high mountain ranges. Each one of these principal branches, inclosed by a range of mountains, is sometimes so low that I have called them mountain hills. There is no doubt that these valleys are partly due to erosion, but they are for the most part synclinal folds, and the intervening mountain ridges are a wedge-like mass of Carboniferous limestone, the beds inclining from both sides like the steep roofs of a house. Not unfrequently the great mass of limestone has been swept away, and the ranges are less lofty and more rounded, exposing to atmospheric agencies the metamorphic rocks, and here are located the valuable mines. Sometimes, through the metamorphic strata, and even the sedimentary rocks, the fluid interior has burst forth, forming a long line of high, black, conical peaks, usually covered with perpetual snows.

We may say of a large portion of Idaho and Montana that the surface is literally crumpled or rolled up in one continuous series of mountain ranges, fold after fold. Perhaps even better examples of these remarkable folds may be found in the country drained by Salmon River and its branches, where lofty ranges of mountains, for the most part covered with limestones and quartzites of the Carboniferous age, wall in all the little streams. None of our published maps convey any idea of the almost innumerable ranges. We might say that from longitude 110° to 118°, a distance of over five hundred miles, there is a range of mountains, on an average, every ten to twenty miles. Sometimes the distance across the range in a straight line, from the bed of a stream in one valley to the bed of the stream in the valley beyond the range, is not more than five to eight miles, while it is seldom more than twenty miles. From these statements, which we believe to be correct, the reader may form some conception of the vast amount of labor yet to be performed to explore, analyze, and locate on a suitable scale these hundreds of ranges of mountains, each one of which is worthy of a name. As we approach the great divide or crest of the water-shed we might suppose that rocks of very ancient date would be the only ones exposed, but those of more modern origin prevail. Rocks older than Carboniferous are the exception. The crest of this water-shed is an irrégular ridge from 7,000 to 8,000 feet above the sea, with here and there along the line, peaks or groups of peaks 9,000 to 11,000 feet high. The lower portions of the

crest are almost entirely destitute of timber of any kind, but are covered over with short grass. The ascent from either side is so gradual that it is difficult to detect the fact that one is passing over the water-shed of the continent. Rocks of all ages, from the Carboniferous to the most modern, Tertiary inclusive, are found.

After passing the divide, we descended the Medicine Lodge Creek toward Snake River Basin. In the Carboniferous limestones on both sides of the valley, the fossils were quite abundant. Among them was a variety of corals, and several species of *Productus*, among them *P. semireticulatus*, &c. The surface, as far as the eye can reach on either side, is extremely rugged, raised into ridges, and cut into deep cañons. Here and there a fine dome-shaped peak rises high above all the rest, 9,000 to 10,000 feet above the level of the sea. The Medicine Lodge Creek commences in little bogs or springs near the divide, and soon the aggregated waters from numbers of little side-valleys, extending down from among the hills and ridges on both sides, form a good-sized trout-stream. I think I never saw a stream, large or small, more fully crowded with trout. There were two species, each equally abundant; and yet this stream sinks beneath the surface and is lost entirely twenty-five miles before reaching Snake River. The limestones and quartzites seem to monopolize the country for a belt of thirty to fifty miles in width, extending east and west on both sides of the divide.

Our camp was made in a singular basin, a sort of synclinal depression, an average of three miles in width and about eighteen miles long, covered over with grass, but no timber, scarcely a shrub. The valley must be at times a complete marsh or bog. It is covered with singular sink-holes. They are round holes ten feet below the surface, and full of rounded bowlders; and in the spring of the year, when the snows on the surrounding hills melt, there is a great accumulation of water, which in the autumn passes away to the main water-courses, among the bowlders underneath the superficial deposit of soil. We see, therefore, that on the very summit of the Rocky Mountain divide, the Pliocene lake deposits occur, as well as immense accumulations of the local drift or Quaternary.

At some future period, in a general *résumé* of the geology of the West, these statements will be referred to. In my preliminary reports I desire to confine myself mostly to a simple statement of what I saw along the route, that the observations may be placed on record for future use. Our first camp on Medicine Lodge Creek was 6,110 feet above the sea. The high mountain hills on either side are 800 to 1,500 feet above the valley, some of the highest peaks 2,500 feet or more. One high ridge of Carboniferous limestone was found to be 700 feet above camp, by barometer. One of the principal features of this valley is a most remarkable deposit from springs, which must have occurred far back in the Pliocene period. It is far the largest I have ever seen in the West, and may serve to illustrate the influence which springs may have in the formation of the earth's crust. It seems to have filled up a synclinal trough. The Carboniferous limestones incline from the sides of the mountains that inclose the valley, and the deposit is arranged in nearly horizontal layers, jutting up against the sides of the valley, while the stream itself has cut its channel through it, thus exposing a fair section to the eye. On the east side of the creek, the wall is 100 to 200 feet high, made up of rather massive layers of most beautiful white limestone, some of it porous like heavy tufa, but most compact like the old Hot Spring limestone on Gardiner's River. Above it, and conforming to the bed of limestone, are about 80 feet of gray volcanic ash, forming a soft, sometimes porous,

chalky rock; this is capped with a layer of very hard, purplish-drab basalt of variable thickness. This deposit extends down the valley of the Medicine Lodge six miles, with an average of four miles in width, and I estimated the entire thickness to be 400 to 600 feet. The deposit itself has been lifted up, so as to form a sort of anticlinal, that is, the strata inclining each way from the river channel at an axis, 5° to 8°. The lower portion is very much like the Hot Springs deposits at Gardiner's River, hard and white as snow; some of it is a pudding-stone, made up of worn pebbles. The upper portion is variable, as if volcanic action had existed at the same time. The limestone in some places passes up into thin layers of a white, fine, calcareous sandstone. As we descend the creek the beds of limestone, volcanic ash, and basalt diminish in thickness, and over all is a heavy bed of black porous basalt. It is probable that during the lake period this valley was the center of one of the most active groups of hot springs on the continent; that the principal time of deposition preceded the last period of volcanic action, when the basalt that covered the Snake River Basin with its huge crust issued forth. We can trace its history step by step by the strata; and although we could discover no sign of any water in the vicinity above the ordinary temperature of river-water, yet there is no doubt that this indicates one of the largest deposits of the kind yet known in the West. We may inquire from what source all this calcareous material was derived. If this is a synclinal valley, and I so regard it, then the vast thickness of Carboniferous limestones which we see on the sides, and extending to the summits of the highest mountains, at least 3,000 feet in thickness, dips down beneath the valley and rises again on the opposite side. The waters permeating such a mass of limestone could dissolve an unlimited amount of lime.

The valley of the Medicine Lodge, for fifteen miles above the Snake River Basin, passes through a deep gorge, with walls of basalt and basaltic conglomerate on either side. At the point where we ascend the hill on the west side of Medicine Lodge, the hot-spring deposits have diminished to about 80 feet in thickness, and, with a flexure like a bow, bend down, beneath the bed of the stream, out of sight. We then have, as the lower portion of the wall, 100 feet of very coarse breccia or conglomerate, capped with a bed of basalt; then 200 feet of yellow material, like marl, undoubtedly volcanic ashes, &c. This also is capped with a bed of basalt. The valley or cañon of the Medicine Lodge is 450 to 550 feet below the sloping plain line. All over the plains there is great abundance of very rough basalt, full of holes, of quite modern origin.

We have said enough in this report to show that the portion of the West drained by the Snake River and its tributaries is full of interest. We have examined only two or three of the numbers of little streams that carve deep channels from the divide down into the basin for more than two hundred miles—all of them undoubtedly presenting features of the highest interest. Fold after fold of mountain ranges extend to the westward to an unknown distance, very few of which are laid down on any of our maps.

CHAPTER IX.

FROM FORT HALL—SODA SPRINGS—BEAR-RIVER VALLEY—BEAR-LAKE VALLEY—TO EVANSTON ON UNION PACIFIC RAILROAD.

I will not delay, at this time, to discuss the many interesting problems connected with the great basin of Snake River. Further examinations will add greatly to the observations we now possess. Indeed, it is hardly possible, in these preliminary reports, to do more than to make a brief record of field-notes. The great lines of thought which are opened up in every direction by the wonderful phenomena of this singular region must be followed persistently to their legitimate conclusions. Time and careful study will be required to work out all the results, and these cannot be given at this period. Our barometric observations indicate the altitude of Fort Hall to be 4,720 feet above the level of the sea. This will form our starting-point homeward from the basin, and, inasmuch as most of the way will be toward higher altitude, we may thus know the grade from point to point.

On our way up to Fort Ellis, in June, we ascended the Cache Valley, and, passing the divide, descended one of the more western branches of the Port Neuf into the Port Neuf Cañon; then into the Snake River Basin. On our return, we crossed the divide between the Blackfoot Fork and the Port Neuf, 5,964 feet, down into a broad valley, a kind of synclinal depression between the high ranges of mountains. In this valley, the sources of the main branch of the Port Neuf gather together before cutting through the ranges of mountains.

I have, in a previous chapter, noted briefly the formations along the east side of the Snake Basin, in the vicinity of Fort Hall. The Jurassic and Carboniferous groups of strata form the bulk of the sedimentary rocks, with the Pliocene or Lake deposits jutting up into the ravines or valleys, and sometimes occurring high up on the sides of the mountains. The range of mountains which formed the eastern wall of the Cache Valley in its northward extension seems to have broken up into irregular fragments after reaching the rim of the basin, and, with the exception of a few rather high peaks, seldom reaches an elevation of more than 6,000 or 7,000 feet on the east border of the basin. I did not observe rocks of Cretaceous or Lower Tertiary age here, though I think a more careful examination will reveal them. Originally there was a system in the formation of the mountain hills on the east side of the basin, but subsequent to their upheaval the outbursts of igneous material have produced apparent chaos. The sedimentary formations at this time incline in every direction and at all angles.

After crossing the divide, we descended into an open, grassy valley, extending to the northern bend of Bear River, averaging about three miles in width, but expanding, near the point where the sources of the Port Neuf unite and cut through the mountains, to a width of five miles. On the east side, the range of hills is entirely composed of Carboniferous limestones, so far as I could ascertain after a careful examination. This range of hills is composed of broken ridges, which rise for 800 to 1,500 feet above the level of the valley. One ridge, which I measured with care, as an average, was 1,100 feet. In many localities these limestones were charged with fossils. In no portion of the Rocky Mountain Range have I seen them of greater abundance and variety. Quite thick layers of a compact, bluish limestone were entirely composed of corals and crinoidal stems. In the valley itself the basaltic covering is exposed here and there, though it is not quite as conspicuous as it is

either east or west of the limestone range. The evidence is plain enough, however, that the basalt did originally form a thick covering in this valley.

Near the bend of Bear River are several points of effusion, and three or four ruins of old craters can be seen. On the east side of the limestone ridges, in the valleys of the sources of the Blackfoot Fork, there are a number of real craters, the rims of which are composed of lava of quite modern appearance. One of these craters, not more than ten miles north of the Soda Springs, is very distinct, about one hundred and fifty yards in diameter, from one edge of the rim to the other, nearly circular; the west side of the rim is about 50 feet above the grass-covered, inner space, which is eighty yards in diameter. All the rocks are extremely porous, and have the appearance of comparatively recent action. Indeed, but few, if any, important changes have taken place in the surface since the eruption of these basalts, and therefore it must have occurred either during or immediately prior to our present period.

In general terms, we may describe this portion of the country as composed of nearly parallel ranges of mountains or mountain hills, seldom rising more than 1,500 feet above the intervening valleys, but with here and there a higher peak 2,000 to 2,500 feet. On the east side and extending off to the drainage of Green River, these ranges are mostly composed of limestones or quartzites, which are undoubtedly of Carboniferous age. They trend nearly north and south, and, though sometimes broken up at points, preserve a remarkable degree of uniformity. They are folds or wrinkles in the crust, from the surface of which nearly or quite all the older sedimentary rocks have been removed by erosion, leaving the Carboniferous group in pretty nearly its full force. On the west side, however, about the lower cañon of the Port Neuf, the limestones have been stripped away, and an immense thickness of metamorphic strata of uncertain age is exposed. In the intervening valleys, are the Lake deposits, as usual, and at a modern date, the evidence of the eruption of the basalt. About the sources of this Blackfoot Fork, the influences of the basaltic outflows are very marked. Along the sides of the ranges of hills or mountains are deep ravines, extending up to the crest or water-divide. They are seldom cañons or gorges, though the walls are in some instances rather abrupt. These ravines gather the drainage from the hills, and in the valleys numerous springs break forth, the waters of which contain great quantities of lime in solution. Large deposits of this lime are met with long before reaching Soda Springs at the bend of Bear River. Indeed, this group of springs, which is usually very remarkable, is but the center of a great district extending in every direction, only the ruins of which remain at the present time. Some of these ruins bear traces, at this time, of a good deal of former beauty. In one locality quite a large area was covered with the semicircular basins, with scalloped rims.

But one of the most remarkable features of this region is the bend of Bear River. By examining the map it will be seen that the river, after flowing nearly northward from the Uintah Mountains about two hundred and fifty miles, makes an abrupt bend, and returns, flowing southward about the same distance into Great Salt Lake, not more than fifty miles from its source. There is really only one important range of mountains or hills between the two portions of the river. I was unable to obtain from the present surface features of the country, a satisfactory reason for the singular conduct of this river. The wide parallel valley which comes up over the lake, known on the maps as Cache Valley, opens directly into the Upper Port Neuf, and continues nearly to Fort Hall, while Bear River

has apparently cut its way directly through one of the great limestone ranges, and abruptly flexes around and flows southward. The river cuts the end of the mountain-range that extends up in the bend, so that the north end forms a high, precipitous mountain wall. The river runs through a deep gorge of basalt. On the opposite side there is a steep wall of limestone 800 to 1,000 feet high. The passage from Upper Port Neuf to Upper Bear River Valley is a narrow gateway about half a mile wide. The general trend of all these ranges is nearly northwest and southeast; the inclination of the limestones 15° to 30°, though in some exceptional cases extensive groups of strata incline as high as 60°.

The high range, which can be seen so distinctly extending far southward from Soda Springs within the bend, is only a portion of the immense limestone range seen on the east side of Cache Valley as we journeyed northward in June. It is entirely composed of the old quartzites and underneath them the well-defined Carboniferous limestones, as shown in the Wahsatch Range, the limestones and the quartzites again overlying the limestones. I could not discover any traces of the usual metamorphic group. There is a broad belt of country lying between the drainage of Snake and Green Rivers, which is formed of a series of folds in the crust, that have not yet been worked out in detail. In all this belt it is seldom that rocks older than the Carboniferous are exposed.

At the bend of Bear River, is located the most interesting group of soda springs known on the continent. They occupy an area of about six square miles, though the number is not great. At this time they may be called simply remnants of former greatness. Numerous mounds of dead or dying springs are scattered everywhere, and only a few seem to be in active operation. So far as the manner of building up the calcareous mounds is concerned, it does not differ from that of the hot springs in the Yellowstone Valley, and it may be that they were boiling springs at some period in the past. At the present time they are not usually much above the temperature of ordinary spring-water. In one or two instances the active springs were found to be luke-warm. Nearly all the springs were in a constant state of more or less agitation from the bubbles of gas that were ever escaping. In a few cases the water is thrown up 2 to 4 feet. One spring with a basin 10 feet in diameter, with the surface covered over with bubbling points from carbonic acid gas escaping, had a temperature of 61½°; another bubbling spring, 65°. The Bear River cross-cuts a number of the mounds, thus revealing the secret of their structure. The mounds vary from a few feet to twenty or thirty feet high, built up, in the same way as the hot-spring cones, by overlapping layers. There are many of these mounds, which show, by the steepness of the sides, the amount of hydrostatic pressure. Many of the chimneys are nearly vertical, with the inner surface coated over with a sort of porcelain. At one point on the margin of Bear River there are two steam-vents, from which the gas is constantly escaping with a noise like a low-pressure engine. Near the edge of the river there is a beautiful spring with a chimney about two feet in diameter lined inside and out with a bright-yellow coating of oxide of iron, in which the water is thrown up two feet by a constant succession of impulses. The inner portions of the chimney are lined with the porcelanic coating as smooth as glass, and tinged through with a bright yellow from its iron. Near the foot of the hills, a mile from the river, there is a soda-spring, with a mound about 10 feet high, with a large rim 30 by 100 feet, but with a small quantity of water compared with what formerly flowed from it; temperature, 53½°. Near this spring are a number of large springs

issuing from beneath the hills of limestone without the deposit or the taste of the acidulous ones; so that we have in close proximity and apparently coming from the same rock, with about the same temperature, acidulous and non-acidulous springs. There were two springs, the waters of which were above the ordinary temperature, respectively, $76\frac{1}{2}^{\circ}$ and 78°.

Near the Mormon village are a number of mounds and springs, which will always attract attention. One of them is located near the margin of Soda Creek. It has formed a small chimney about $2\frac{1}{2}$ feet in diameter, 6 feet above the creek, and the water boils up most violently. One would suppose from the agitation of these springs that a large quantity of water must necessarily flow from them; but the quantity is always small, and in some cases none. In the middle of Soda Creek, which at this point is about 25 feet wide and 3 feet deep, there are several points of ebullition, showing the presence of springs beneath. Within 100 feet of the fine spring owned by Hon. W. H. Hooper, there are three singular cone-shaped chimneys with water in a constant state of ebullition, but with no visible outlet. All around these springs there is a deposit of iron of a bright-orange color. In the bed of Bear River there are a number of springs which can be seen from a distance by the ebullition. Although the flow of water from these springs does not seem to be great, yet there will always be enough for the demand of visitors for drinking purposes. There are some mounds that have been built up in thin layers and rounded gradually to their summits, 30 to 50 feet high, and from 50 to 300 feet in diameter at the base; these have been at a former period, large springs, but are now in their last stages. Some of these springs have gradually built up a mound in the form of a haycock or a bee-hive, and before dying or breaking out in another place would close themselves up at the summit. One of the largest of these mounds closed itself up at the top, all except a chimney about 4 feet in diameter, with an aperture of about 4 inches. It was once a spring of great force, but gradually died away until it ceased entirely. But the most interesting exhibition of the soda-spring deposit is found on Soda Creek, about four miles above its junction with Bear River. There is here an area of half a mile square, covered over with the semicircular reservoirs, with scalloped rims, similar to those on Gardiner's River, except that they are much coarser. Some of the rims are 6 and 8 feet high. The process of building up these reservoirs is going on now, but the center of operation is constantly changing. The partitions of these reservoirs are sometimes several feet in thickness, and are usually hollow, forming extensive caverns. The inner sides are most beautifully lined with a calcareous bead-work like coral, as white as snow. There are also rows of small stalactites, which add much to the ornamentation. All around these springs, in the channels along which the water flows, the vegetation grows with a rankness which is worthy of special notice. As the waters holding lime in solution flow slowly over this vegetation, the leaves and stems become incrusted, and large masses may be gathered up as specimens, showing the stems and leaves perfectly. These specimens have been transported in large quantities to different points along the Pacific Railroad for the purpose of sale to travelers and curiosity-seekers, until these beautiful decorations are destroyed. When I visited these springs last autumn I found them a mass of ruins, and the specimens that I obtained for the museum of the Smithsonian Institution were those that had been rejected by these traders. From the base of the Limestone Hills, which are 500 to 800 feet high, springs gush out, forming at once a swift-flowing stream, 6 feet wide and a foot

deep, as clear as crystal. The valley of Soda Creek extends off to the northwest and unites with that of Blackfoot Fork. As far as the eye can reach only a fragment of a ridge of limestone, or an old volcanic crater, can be seen, but on either side the high limestone hills rise up like lofty walls. The basalt is shown along the base of these hills in high, vertical walls, 50 to 80 feet, breaking into irregular columnar masses. Sometimes the springs sink beneath this crust of basalt, and thus disappear for a long distance. Huge fissures and sink-holes are not uncommon. These limestones, from the inclination as shown in the surrounding hills, must dip beneath all the Lake deposits and basaltic floors of the valleys, and consequently the water of the springs may pass up through 2,000 to 4,000 feet of limestone. A narrow-gauge railroad has been projected, and partially constructed, by the Mormon authorities, from the Pacific Railroad, near Ogden, via Cache Valley, to Soda Springs. This road will pass through the most thickly settled and most prosperous portion of Utah outside of Salt Lake Valley. It also opens up the fine valley of Upper Bear River with its 2,500 industrious farmers. I call the attention of the public to this locality, Soda Springs, as a future place of resort for pleasure-seekers and invalids. The numerous springs with their curious deposits, the beautiful valley with its river, surrounded with most picturesque scenery, must very soon attract great attention from tourists. About sixty miles to the northeast, on Salt Creek, a branch of John Gray's River, are some of the finest salt-works west of the Mississippi, which must sooner or later attract far more attention than they have yet done.

The elevation at Soda Springs is 5,529 feet above the level of the sea. From this point we pass up the valley of Bear River, constantly, but gradually ascending to higher altitudes until we reach the terminus of our journey. We shall find the soil fertile, the vegetation exuberant, the crops of the farmers usually good. We shall be constantly surprised at the numbers of prosperous villages that will greet our eyes every few miles. When the valley was first settled, a few years ago, the crops were all destroyed either by grasshoppers or early and late frosts. The prospects of the farmers are improving every year, and as the country becomes settled, the climate seems to become milder and the confidence and prosperity of the people are greatly increasing.

I have continually spoken of the Lake deposits in the valleys among the mountains, from the fact that they occur everywhere. There is also a remarkable uniformity in their mineral composition and color. Still there is here and there a locality where these deposits present some variations from the usual type. About three miles above Soda Springs, on the margin of Bear River, there is a bed of black slaty clay underneath the superficial deposits of drift, which contains a seam of impure coal, visible only when the water is low in autumn. The slate above the coal is literally crowded with fresh-water shells, as *Planorbis*, &c. The beds are all horizontal and form a portion, I suspect, of the Pliocene Lake deposits of these valleys. A little farther up the river, on the opposite side, there are hills, cut by the river, showing about 200 feet of gray indurated sandstones, with beds of pudding-stones, and light-gray and whitish marly sand and clay, a very modern deposit, but attaining such a thickness and giving form to the high hills bordering the river as to be regarded as worthy of attention in describing the geological features of this valley. I may state in short that for ten miles the valley and the foot-hills on either side exhibit an extensive deposit, gradually passing up into the Quaternary or Drift, and over the Drift is here and there a crust of basalt. There are also old spring de-

posits in the form of rather compact tufa. On either side of the river the high mountain hills are composed of quartzites and Carboniferous limestones.

About fifteen miles above Soda Springs the river cuts through a vast thickness of thin shales, varying in thickness from one-twentieth of an inch to an inch, averaging about one-eighth of an inch thick, resembling the Green River shales on the Union Pacific Railroad. They are mostly horizontal, but occasionally incline 3° to 5°. They reach a thickness of 500 to 800 feet and appear to pass up into variegated beds of light-gray and pink sands and clays in this valley, resembling those of the Wahsatch group west of Fort Bridger. By looking at the map it will be observed that the valley of Green River is only about sixty miles to the eastward, while southward the variegated beds are found filling up the inequalities of the surface of the older rocks as far as the eye can reach, on either side of our road to Evanston. The appearance of the large mass of shales in the valley of Bear River is not easily accounted for, and they do not appear to conform to the older rocks. No fossils could be found in the shales, and all that I can say of them is that they appear to be of modern Tertiary age, and that in the scooping out of the valley they seem to have escaped the general erosion. About fifteen miles below Soda Springs, are some thick local deposits of the white lime stone, very compact and hard enough for building material or lime. This fact is mentioned to show that these spring deposits, whether hot or cold, extended far back into the past, at least to the Pliocene period, like those in the Yellowstone Valley. I have no doubt, however, that the springs of Bear River Valley were originally hot, perhaps some of them geysers at a former period.

The only method which I could take to ascertain the general geology of the mountains on either side of the valley was to follow up the gorges worn out by some of the little mountain streams. East of Bennington the quartzites are well exposed, covering the side and summits of the mountains and inclining at various angles towards the valley. These quartzites, although so very hard and compact, have a brittle fracture, and the sides and base of the mountains are covered with vast quantities of the *débris*. Following along the base of the mountains, the limestones soon rise from beneath the quartzites, and at Joe's Gap, near the town of Bennington, there is a gorge in the side of the mountain that forms a remarkably clear section of the strata. The little stream that carved out the gorge is now entirely dry, and must be supplied in the spring by the melting of the snows. The gorge itself is about 300 feet wide, with nearly vertical walls 500 feet high. The upper 200 feet of strata are very massive, yellowish-gray, hard, and quite pure limestone. The lower 300 feet are composed of layers, varying in thickness from an inch to 2 feet, and very regular. The rock is very hard, tough, bluish or steel-gray, calcareous mud, with all the peculiar markings of a shallow-water mud-deposit. Fossils are abundant in the limestones. The entire mass flexes over the sides of the mountain, with a curve toward the top, inclining 10° to 15°, and at the base 20° to 30°. Of course, the strata pass beneath the valley, and rise again on the opposite side. Bear River Valley is a synclinal depression. To the eastward a series of three synclinal folds may be seen, extending nearly to Green River, filled up, in some instances, with the variegated beds of the Wahsatch group. Above Bennington the valley begins to expand and forms a wide, marshy flat, with a soil composed of rich, black earth, sustaining a thick growth of coarse grass. There is no timber along the river except willows, and the high hills

are thickly covered with pines. At Paris the rocks used for building purposes are obtained from the Wahsatch group, in the lower hills, on the west side of the river. From Montpelier, for about ten miles up the valley, there is a break in the hills on the east side, and they become much lower; but opposite Bloomington a higher range comes in and continues far southward. The little streams, which are very abundant, especially on the west side of the valley, rise mostly at the foot of the hills, and vary from one mile to four miles in length. Some large streams, ten to fifteen yards wide and one to two feet deep, flow into Bear Lake from a group of springs gushing out of the sides of the hills not over a mile distant. The climate may be severe in this valley, but the inhabitants are of the belief that it is becoming milder every year. I was continually amazed at the evidences of prosperity everywhere. Pleasant villages are located every few miles, and in the interval are numbers of well-improved farms. The soil of this valley is more fertile than that of Salt Lake Valley, and is better watered. There is no lack of springs and streams for irrigation or for milling purposes. The timber is very scarce, but sufficient for fuel is obtained from the mountains, and there is no limit to the supply for building materials.

Just before reaching the lake, we leave the river to the east and enter the Bear Lake Valley. This must have been a large lake at one time, at least twenty-five miles long and from six to ten broad; at the present time it is ten miles in length and from five to eight broad. At the boundary line, between Idaho and Utah, passing directly across the lake from east to west, I was informed that Mr. Majors, the astronomer in charge, under the General Land-Office, made the width of the lake, by triangulation, seven and one-third miles. From the mouth of Swan Creek the width was at one time measured with a chain on the ice and found to be seven and three-fourths miles. Soundings were also made from the mouth of Swan Creek to the opposite side, and the greatest depth was determined to be 175 feet. One mile west from Indian Creek, on the east side, the depth was 137 feet; so that we may estimate the average depth at 40 to 60 feet. It is a beautiful lake, set like an emerald among the mountains. Not even the waters of the Yellowstone Lake present such vivid coloring. No sea-green hue could be more delicate; and as the waves rolled high by the force of the winds, the most vivid green seemed to shade to a beautiful, delicate blue. Bear River seems to have been bent slightly out of its course by a range of mountains which extends northward between the lake and the river, but it suddenly flexes back again, even south of west, and then flows to the northwest. I was unable to make an examination of this portion of the river, and therefore cannot present the geology in detail, but hope to continue these explorations at some future time.

By examining the map it will be seen that there is but a single range of mountains between Cache Valley and Bear River, and that the geological structure does not differ materially from that of the Wahsatch Range and its subordinate ranges. We have a vast thickness of very hard quartzites at the base, and above them a group of limestones, which, so far as Bear River Valley is concerned, has yielded only fossils of Carboniferous species. Above the limestones are quartzites again, with intercalated layers of clay and sandstones. The lower quartzites appear to have been partially metamorphosed, and contain some quite rich silver ores. These ores do not appear to be found in regular lodes but in pockets or irregular cavities. At the time my party passed up the valley there was a good deal of interest in these mines among the people, and some very excellent specimens of the ores were shown to us.

West of Bloomington, Paris, Saint Charles, and the lake, a number of mines have been located. I had the opportunity of examining but one of the mines, and that was near the mouth of Swan Creek. It was ocated in the quartzites, as I have described above. From all the evidence that I could obtain, I formed the opinion that these mines would never become very profitable, though quite interesting in a scientific point of view. They deserve a much more careful examination than I was able to give them.

As I have before stated, the valley of Bear Lake is most beautiful, fertile, and already well settled by farmers. There are all the indications of prosperity, yet I understand that the winters are very severe, and that, owing to the late and early frosts, crops are uncertain. Still the climate is reported to be growing milder every year. We may look for a moment at the elevation of the valley above the sea. At Soda Springs, the most northern point of Bear River Valley, the elevation is 5,529 feet; at Bear River Bridge, thirty-three miles up the valley, 5,744 feet; at Swan Creek, on the west side of the lake, twenty-five miles farther up the valley, 5,922 feet. At the extreme south end of the lake the elevation was found to be 5,931 feet. We see, therefore, while this most attractive portion of the valley is not above 6,000 feet, the successful raising of crops is even yet somewhat problematical, though the parallel of latitude is only 42°.

Near Swan Creek there is a fine exhibition of a local anticlinal. The beds of quartzites incline like a steep roof from the west side of the mountain, forming a wall very near the road. The inclination of the quartzites was 60°, while all along the sides of the mountains the basalt ridges of the strata are shown inclining in an opposite direction 10° to 15°. The east portion of this anticlinal is undoubtedly due to the washing out of the underlying materials by the waters of the lake and the breaking down of the beds of quartzite in consequence. The hills or mountains on the west side rise 1,000 to 1,200 feet above the lake. Bear Lake Valley is oval in shape and at the present time has the appearance of an anticlinal. The high ranges of hills on the west side only present the basalt edges of the strata toward the lake, but it is probable that the western portion has been swept away by erosion. It is possible that the system of synclinal folds or depressions extended along the valley, but have been worn away. At the upper end are fragments of anticlinal ridges, which appear to have extended across the area now occupied by the waters of the lake. On the east side the streams have cut deep gorges into the hills, revealing the quartzites as well as the limestones, but the variegated clays, marls, and sandstones of the Wahsatch group repose unconformably upon them, filling up the irregularities of the surface and concealing the older rocks for the most part. The quartzites prevail on the west side, extending as far southward as the eye can reach, while in the valley at the extreme south end very compact quartzites, which appear to be partially changed, crop out from beneath the Carboniferous limestones.

After crossing Spring Creek, near Laketown, we enter a deep cañon with massive strata of limestone, inclining about northeast 50° to 70°. We have at the bottom, first, very irregular bedded, massive, cherty limestone, with no fossils; secondly, a yellow, calcareous sandstone of varied texture; thirdly, limestone in thin strata, very much warped or bent. The upper limestones are much like those in Joe's Gap east of Bennington, and are, no doubt, a continuation southward of the same ridge. This ridge, or range of mountain hills, as it might be termed, is deeply gashed by streams that flow into the lake or river, revealing sections of the strata more or less clear. We may, therefore, state in

general terms that the metamorphic quartzites crop out occasionally, though seldom, but high ridges of Carboniferous limestones, with the strata inclining at all angles, are frequently uncovered over large areas. From Soda Springs to the south end of the lake, and even much farther southward, the high ranges of hills on the east side are composed of a nucleus of limestones uncovered here and there. Sometimes a vast thickness of the variegated quartzites conform to and conceal the limestones, while in the intervals between these great anticlinal ridges, and sometimes covering them, is a vast thickness of the more modern deposits of the Wahsatch group. Ascending the divide eastward from Bear Lake Valley, I estimated the thickness of the older strata to be 6,000 feet, 4,000 of which are Carboniferous limestones and the remainder quartzites and sandstones. From the summit to Bear River Valley the variegated beds of the Wahsatch group conceal all the older rocks.

From the divide we descended the valley of Sage Creek to Bear River Valley. The Tertiary strata are nearly horizontal on either side. These rather modern beds partook of some of the later movements, and incline at angles from 1° to 10°. The valley where we entered it is about three miles in width, and soon expands to five miles. About five miles below the village of Randolph, on the east side of Bear River, there is one of the ruggedest walls of Carboniferous limestone I have seen on the trip. The rocks seem to rise up from the river-bottom almost vertically; the summits are weathered into jagged points, and the sides of the wall, from summit to base, are gashed with dry cañons or gulches, which form splendid cross-sections of the strata. The trend of the ridge is about northeast and southwest; the dip northwest 60° to 70°. The limestone is usually pure, light-gray color, not as compact as usual, full of fossils, mostly in a fragmentary condition. Still these fossils show most clearly that the limestones are of Carboniferous age. This range of mountains, as it might properly be called, forms a very singular exhibition of the dynamic forces that have produced the remarkable folds in the older sedimentary rocks. It may be called an oblong quaquaversal, or an isolated puff or bulge in the crust. The entire range is not over eight miles in length and not over two or three miles wide. The limestones bend down from the summits like the steep, flexible, convex roof of a house. About three miles above Randolph, at the bend of the river, the limestone ridge breaks off suddenly. On the south end the strata seem to be inclined at a greater angle, in some instances passing a vertical. A fragment has been cut off at the south end, where a stream has at some period very remote in the past made its way through. This section shows the strata clearly, and as well the way they flex down around the end of the range. The bend of Bear River is not long, but quite abrupt. Far to the south the country is open, flat, and appears like a river valley, surrounded by low hills. The character of this limestone range would indicate depression of the surrounding country as one of the causes of the convex form of the sides. At any rate, within the space of about ten miles from east to west, there are two of these remarkable limestone ridges, where 3,000 to 4,000 feet of strata seem to be corrugated into quite remarkable folds, with synclinal intervals that have been filled up with the modern Tertiary beds.

I will not delay at this time to discuss the causes that may have led to this wrinkling of the crust, but simply state my observations and wait patiently for a greater array of facts. From the bend of Bear River to Evanston the strata are not much disturbed, usually not inclining more than from 3° to 10°. In the cañon southeast of the bend I was informed that coal had been found. From the end of the limestone ridge to the railroad, in every direction, the rocks exposed are not older than

the Coal group, probably Lower Tertiary or Upper Cretaceous. At Evanston we have the great coal-mines, which have been described to some extent in my previous reports, and are still further described by Dr. Peale in a subsequent portion of this report. The numerous species of plants which were found above and below the coal-beds are described in the report of Professor Lequereux on the fossil plants collected by the expedition. I had intended to add some additional chapters, and a final one, which should comprise a *résumé* of the geology of the country examined during the past season, but the time would not permit. It is my purpose to press on with all the vigor possible to collect the facts which shall establish the age of the different formations of this portion of the West; more especially to ascertain the relation the coal-beds sustain to the Cretaceous and Tertiary periods.

NOTES TO CHAPTER IX.

The following letter of Dr. Drown conveys so much valuable information in regard to the chemical character of the remarkable Soda Springs at the base of Pike's Peak, Colorado, that I am glad to append it to this chapter, for the purpose of comparison with the waters at Soda Springs, on Bear River. The letter is published by permission of Dr. R. H. Lamborn. The information is of greater interest to me, from the fact that the springs were examined with some care by my party in 1869, and a short account of them was given in my report of the United States Geological Survey of Colorado and New Mexico:

LABORATORY, 209 SOUTH SIXTH STREET,
Philadelphia, November 11, 1871.

DEAR SIR: I take pleasure in transmitting to you the results of my examination of the salts placed in my hands through the kindness of yourself and Professor Persifor Frazer, jr. These salts were the residue of evaporation of the water of the spring called the "Doctor," one of the well-known group of mineral springs at the foot of Pike's Peak, Colorado, now reached by the Denver and Rio Grande Railway; which springs, I understand, now belong to the Fountain Colony, and are about to be improved with a view to the utilization of their sanitary qualities. The substance submitted for analysis was obtained by Professor Frazer, jr., from the spring in question when engaged on the mineralogical survey of Colorado in 1869, and was the result of the evaporation of a considerable quantity of water. The means at hand for evaporation were so crude that some substances, not properly belonging to the water as it comes from the earth, have become mixed with the material used in my determinations; but their nature is such that I think they may be readily eliminated, leaving the ultimate result quite accurate.

The result of the analysis was as follows:

	Per cent.
Organic matter	9.33
Sesquioxide of iron	4.49
Alumina	0.87
Silica and quartz	6.10
Lime	5.64
Magnesia	2.57
Potassium	4.86
Sodium	21.60
Oxygen by calculation	2.87

	Per cent.
Carbonic acid	11.80
Sulphuric acid	2.49
Chlorine	25.02
	97.64

The 2.36 per cent. unaccounted for I consider to be principally due to a too low determination of the organic matter, the estimation of which was attended with difficulties, and the small amount of material at my disposal precluding a redetermination.

The organic matter found in such large quantity was evidently mainly communicated to the water during evaporation, and could scarcely have been contained in the water itself. Professor Persifor Frazer, jr., says the spring is not perceptibly ferruginous, so that the iron found was doubtless from the kettle in which the water was evaporated. The quartz was present in pieces of appreciable size, and must have been mechanically suspended in the effervescing water. The small amount of alumina found may have been in solution in the water, but more probably accompanied the quartz. Eliminating these substances from the analysis, we may express the composition of the solid ingredients of the water as follows:

	Per cent.
Chloride of sodium	33.96
Chloride of potassium	9.27
Carbonate of soda	10.94
Sulphate of soda	4.42
Silicate of soda	5.49
Carbonate of lime	10.07
Carbonate of magnesia	5.40

Calculating these amounts on the scale of 100 parts, and presuming that the soda, in combination with the silicic acid, was originally in combination with carbonic acid, and calculating, moreover, the carbonated salts as bicarbonates, we have:

	Per cent.
Chloride of sodium	36.69
Chloride of potassium	10.01
Bicarbonate of soda	24.01
Sulphate of soda	4.78
Bicarbonate of lime	15.62
Bicarbonate of magnesia	8.89
	100.00

The water of the spring is thus shown to belong to the class of mineral waters characterized by a preponderance of alkaline chlorides and carbonates. This class of waters has its principal German types in the springs at Ems and Selters in Nassau, analyses of which are appended for comparison.

	Krähuchen Spring, Ems.	Selters Spring.		Doctor Spring.	
	Per cent.	*Per cent.*		*Per cent.*	
Chloride of sodium	27.25	51.68	52.53	36.69	46.70
Chloride of potassium	....	0.85		10.01	
Bicarbonate of soda	57.03	29.29		24.01	
Sulphate of soda	0.56	0.76		4.78	
Bicarbonate of lime	6.65	8.00		15.62	
Bicarbonate of magnesia	5.83	7.65		8.89	
Bicarbonate of iron	0.67	0.29		....	

The Krähuchen Spring is the one chiefly used for drinking at Ems. This watering-place is stated in Dr. McPherson's recent work to be the most popular woman's bath in Europe; he adds that this watering-place is well suited for cases of bronchial and laryngeal catarrh.

From the close correspondence between the Doctor Spring and the Selters Spring, in chemical composition, we can infer that the physiological effects of these waters will be very similar. Of the far-famed Selters Spring, which supplies the world annually with a million and a half bottles of Selters water, Dr. Edwin Lee writes: 'Its action is, in general, cooling, exhilarating, and alterative, improving vitiated secretions of the mucous membranes, giving tone to their glands, and promoting absorption. It may generally be taken without risk by robust and plethoric individuals, and is of great service in cases of torpor of the vascular and glandular systems, stomach derangement, with acidity and constipation, tendency to gout in full habits, and scrofulous complaints. The Selters water would also be serviceable in cases of irritation of the urinary organs, or tendency to the formation of stone or gravel in chronic inflammation of the mucous membrane of the bladder.

THOMAS M. DROWN, M. D.

ROBERT H. LAMBORN, Esq., *Vice-President*
Denver and Rio Grande Railway.

While my party was engaged at Soda Springs, I obtained some valuable information from Mr. Stump, one of the proprietors of the Oneida Salt Works, Idaho, which indicates the existence of some of the most valuable salt-springs on our continent. I was not able to visit them, and these few notes are given here for the purpose of directing the attention of the public to them. They are located in a small side-valley, which opens into Salt Creek, a branch of John Gray's River, about sixty miles northeast of Soda Springs. They are surrounded with high mountains. The little creek in which the springs are located flows southeast, while the main Salt Creek runs northwest. The water is as cold as ordinary spring-water, and is as clear as crystal, showing how completely the saline matter is held in solution. The market is in Idaho and Montana—mostly in Montana. The company make 6,000 pounds of salt per day, but the supply of water would warrant 25,000 pounds per day. There is another small spring, a little distance from the main springs, that yields water enough for 2,000 pounds of salt per day for a portion of the year. It sells at $30 per ton at the works, and the demand is increasing every year. The company began to supply the market in 1866 at five cents per pound. It now sells at two cents per pound. The amount annually made by the company for six years past is as follows:

	Pounds.		*Pounds.*
1866	100, 000	1869	650, 000
1867	300, 000	1870	750, 000
1868	500, 000	1871	850, 000

Analysis of sample of salt from White & Stump Oneida Salt Works, Oneida County, Idaho, by A. Snowden Piggot, M. D.

Chloride of sodium	97. 79
Sulphate of soda	1. 54
Chloride of calcium	0. 67
Sulphate of magnesia	Trace.
	100. 00

CHAPTER X.

THE YELLOWSTONE NATIONAL PARK.

[With a map.]

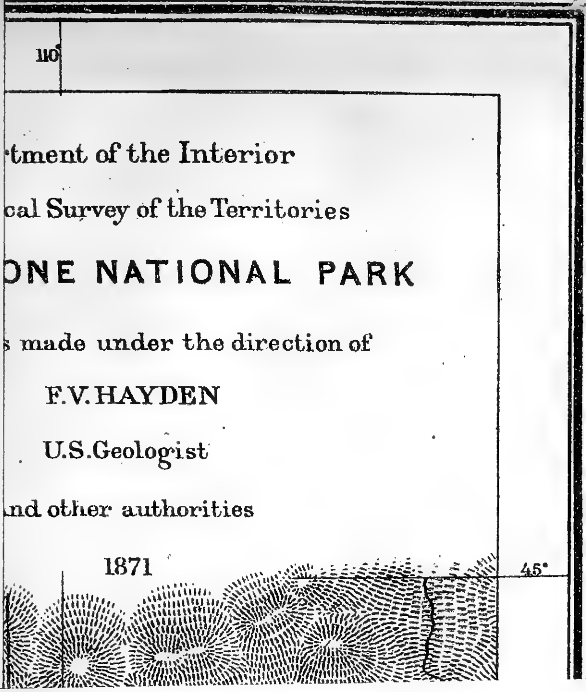
While the preceding chapters of this report were passing through the press, the bill that was introduced into both Houses of Congress in December has become a law. It will perhaps be proper, therefore, to devote a small space to a notice of this event, omitting the details until the more complete history can be prepared.

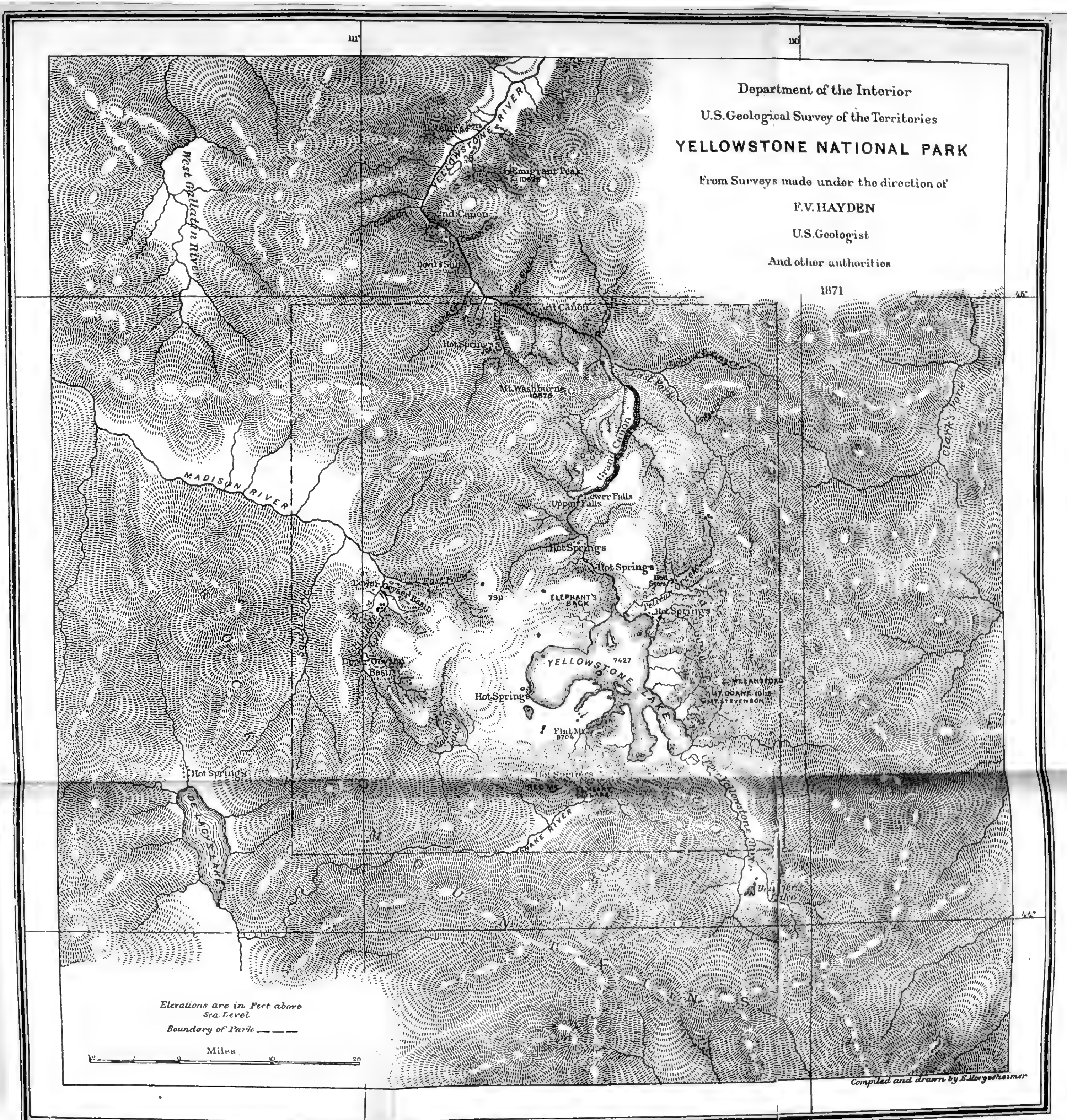
In order that the geographical locality of the reservation, containing within its boundaries the wonderful falls, hot-springs, geysers, &c., described in the previous chapters of this report, may be more clearly understood, I have prepared a map expressly to show the park with its surroundings, on a scale of ten miles to one inch. The report of the Committee on Public Lands, as well as the law itself, which is included in this chapter, will serve to explain the map in general terms. A glance at the map will show to the reader the geographical locality of the most beautiful lake in the world, set like a gem among the mountains. He will also see that the mountains that wall it in on every side form one of the most remarkable water-sheds on the continent. The snows that fall on the summits give origin to three of the largest rivers in North America. On the north side are the sources of the Yellowstone; on the west, those of the Three Forks of the Missouri; on the southwest and south, those of the Snake River, flowing into the Columbia and thence into the Pacific Ocean; and those of Green River, rushing southward to join the great Colorado, and finally emptying into the Gulf of California, while on the east are the numerous sources of Wind River. From any point of view which we may select to survey this remarkable region, it surpasses, in many respects, any other portion of our continent.

On the 18th of December, 1871, a bill was introduced into the Senate of the United States by Hon. S. C. Pomeroy, to set apart a certain tract of land lying near the head-waters of the Yellowstone River as a public park. About the same time a similar bill was offered in the House of Representatives by Hon. William H. Claggett, Delegate from Montana. After due consideration in the Committees on Public Lands in both Houses, the bill was reported favorably. In the Senate it was ably advocated by Messrs. Pomeroy, Edmunds, Trumbull, Anthony, and others. In the House the remarks of Hon. H. L. Dawes were so clear and forcible that the bill passed at once without opposition.

I have thus presented a brief history of the passage of this bill because I believe it will mark an era in the popular advancement of scientific thought, not only in this country, but throughout the civilized world.

That our legislators, at a time when public opinion is so strong against appropriating the public domain for any purpose however laudable, should reserve, for the benefit and instruction of the people, a tract of 3,578 square miles, is an act that should cause universal joy throughout the land. This noble deed may be regarded as a tribute from our legislators to science, and the gratitude of the nation and of men of science in all parts of the world is due them for this munificent donation.


110°
·tment of the Interior
cal Survey of the Territories
ONE NATIONAL PARK
s made under the direction of
F.V. HAYDEN
U.S.Geologist
ınd other authorities
1871
45°


Department of the Interior
U.S. Geological Survey of the Territories
YELLOWSTONE NATIONAL PARK
From Surveys made under the direction of
F.V. HAYDEN
U.S. Geologist
And other authorities
1871
111°
110°
45°
44°
YELLOWSTONE RIVER
Emigrant Peak
2nd Cañon
Devil's Slide
Hot Springs
Mt. Washburne
10575
East Fork
Clark's Fork
Grand Cañon
Lower Falls
Upper Falls
West Gallatin River
MADISON RIVER
Lower Geyser Basin
Upper Geyser Basin
ELEPHANT'S BACK
YELLOWSTONE LAKE
7427
MT. LANGFORD
MT. DOANE
MT. STEVENSON
Flat Mt.
8704
RED MT.
SNAKE RIVER
Yellowstone River
DE LACY'S LAKE
Elevations are in Feet above Sea Level
Boundary of Park
Miles
10
20
Compiled and drawn by E. Hergesheimer

THE YELLOWSTONE PARK.

Mr. DUNNELL, from the Committee on the Public Lands, made the following report:

The Committee on the Public Lands, having had under consideration bill H. R. 764, would report as follows:

The bill now before Congress has for its object the withdrawal from settlement, occupancy, or sale, under the laws of the United States, a tract of land fifty-five by sixty-five miles, about the sources of the Yellowstone and Missouri Rivers, and dedicates and sets it apart as a great national park or pleasure-ground for the benefit and enjoyment of the people. The entire area comprised within the limits of the reservation contemplated in this bill is not susceptible of cultivation with any degree of certainty, and the winters would be too severe for stock-raising. Whenever the altitude of the mountain districts exceeds 6,000 feet above tide-water, their settlement becomes problematical unless there are valuable mines to attract people. The entire area within the limits of the proposed reservation is over 6,000 feet in altitude, and the Yellowstone Lake, which occupies an area fifteen by twenty-two miles, or three hundred and thirty square miles, is 7,427 feet. The ranges of mountains that hem the valleys in on every side rise to the height of 10,000 and 12,000 feet, and are covered with snow all the year. These mountains are all of volcanic origin, and it is not probable that any mines or minerals of value will ever be found there. During the months of June, July, and August the climate is pure and most invigorating, with scarcely any rain or storms of any kind, but the thermometer frequently sinks as low as 26°. There is frost every month of the year. This whole region was, in comparatively modern geological times, the scene of the most wonderful volcanic activity of any portion of our country. The hot springs and the geysers represent the last stages—the vents or escape-pipes—of these remarkable volcanic manifestations of the internal forces. All these springs are adorned with decorations more beautiful than human art ever conceived, and which have required thousands of years for the cunning hand of nature to form. Persons are now waiting for the spring to open to enter in and take possession of these remarkable curiosities, to make merchandise of these beautiful specimens, to fence in these rare wonders, so as to charge visitors a fee, as is now done at Niagara Falls, for the sight of that which ought to be as free as the air or water.

In a few years this region will be a place of resort for all classes of people from all portions of the world. The geysers of Iceland, which have been objects of interest for the scientific men and travelers of the entire world, sink into insignificance in comparison with the hot springs of the Yellowstone and Fire-Hole Basins. As a place of resort for invalids, it will not be excelled by any portion of the world. If this bill fails to become a law this session, the vandals who are now waiting to enter into this wonder-land will, in a single season, despoil, beyond recovery, these remarkable curiosities, which have required all the cunning skill of nature thousands of years to prepare.

We have already shown that no portion of this tract can ever be made available for agricultural or mining purposes. Even if the altitude and the climate would permit the country to be made available, not over fifty square miles of the entire area could ever be settled. The valleys are all narrow, hemmed in by high volcanic mountains like gigantic walls.

The withdrawal of this tract, therefore, from sale or settlement takes nothing from the value of the public domain, and is no pecuniary loss to the Government, but will be regarded by the entire civilized world as a step of progress and an honor to Congress and the nation.

DEPARTMENT OF THE INTERIOR,
Washington, D. C., January 29, 1872.

SIR: I have the honor to acknowledge the receipt of your communication of the 27th instant, relative to the bill now pending in the House of Representatives dedicating that tract of country known as the Yellowstone Valley as a national park.

I hand you herewith the report of Dr. F. V. Hayden, United States geologist, relative to said proposed reservation, and have only to add that I fully concur in his recommendations, and trust that the bill referred to may speedily become a law.

Very respectfully, your obedient servant,

C. DELANO,
Secretary.

Hon. M. H. DUNNELL,
House of Representatives.

The committee, therefore, recommend the passage of the bill without amendment.

[GENERAL NATURE—No. 16.]

AN ACT to set apart a certain tract of land lying near the head-waters of the Yellowstone River as a public park.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the tract of land in the Territories of Montana and Wyoming, lying near the head-waters of the Yellowstone River, and described as follows, to wit, commencing at the junction of Gardiner's River with the Yellowstone River, and running east to the meridian passing ten miles to the eastward of the most eastern point of Yellowstone Lake; thence south along said meridian to the parallel of latitude passing ten miles south of the most southern point of Yellowstone Lake; thence west along said parallel to the meridian passing fifteen miles west of the most western point of Madison Lake; thence north along said meridian to the latitude of the junction of the Yellowstone and Gardiner's Rivers; thence east to the place of beginning, is hereby reserved and withdrawn from settlement, occupancy, or sale under the laws of the United States, and dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people; and all persons who shall locate or settle upon or occupy the same, or any part thereof, except as hereinafter provided, shall be considered trespassers and removed therefrom.

SEC. 2. That said public park shall be under the exclusive control of the Secretary of the Interior, whose duty it shall be, as soon as practicable, to make and publish such rules and regulations as he may deem necessary or proper for the care and management of the same. Such regulations shall provide for the preservation, from injury or spoliation, of all timber, mineral deposits, natural curiosities, or wonders within

said park, and their retention in their natural condition. The Secretary may, in his discretion, grant leases for building purposes for terms not exceeding ten years, of small parcels of ground, at such places in said park as shall require the erection of buildings for the accommodation of visitors; all of the proceeds of said leases, and all other revenues that may be derived from any source connected with said park, to be expended under his direction in the management of the same, and the construction of roads and bridle-paths therein. He shall provide against the wanton destruction of the fish and game found within said park, and against their capture or destruction for the purposes of merchandise or profit. He shall also cause all persons trespassing upon the same after the passage of this act to be removed therefrom, and generally shall be authorized to take all such measures as shall be necessary or proper to fully carry out the objects and purposes of this act.

Approved March 1, 1872.

CHAPTER XI.

REPORT OF A. C. PEALE, M. D., ON MINERALS, ROCKS, THERMAL SPRINGS, &C.

WASHINGTON, D. C.

DEAR SIR: I have the honor to transmit herewith my preliminary report on the minerals, rocks, and thermal springs met with during the explorations of this summer.

I commence at Ogden, Utah Territory, our starting-point, and describe the minerals, rocks, and springs encountered by the expedition throughout the whole trip. To study the mineral resources of a country to the best advantage requires that we should have an abundance of time to devote to each locality, working on our knees, as it were, with drill and hammer. As the greater part of our time was spent on the march, such a course was impracticable; I therefore confined myself to the collection and general investigation of specimens.

Six hundred and twenty-seven specimens of rocks, with over one thousand specimens of minerals, including those from the hot springs, have been deposited in the Smithsonian Institution. Catalogues of the minerals and rocks are appended to this report.

I insert qualitative analyses of the waters of the principal geysers and hot springs. In so doing, I feel a hesitancy, for the field is so vast that to develop it thoroughly would require the work of years, and the number I present is but as a drop of water in the ocean.

I had hoped to embody in this report a larger number of quantitative analyses, but the time has been limited, and there have been interruptions that have rendered it impossible.

I append a catalogue of the hot springs of which the temperatures were recorded, giving their position, elevation, character, principal constituents, highest, lowest, and average temperatures, together with the temperature of the air at the time of observation.

In regard to mining operations, I have not attempted to make any report. We passed through but a small portion of the mining districts, so that any such report would be incomplete.

In conclusion, I wish to express my thanks to the members of the expedition for their assistance and co-operation, and also to Judge Lovell, of Virginia City, Montana Territory, and C. T. Deuel, esq., of Evanston,

Utah, for information afforded me. I would also refer to the uniform kindness and courtesy extended to us at the various military posts.

Hoping this report may meet all requirements, I am, very respectfully, your obedient servant,

A. C. PEALE.

Dr. F. V. HAYDEN,
United States Geologist.

Ogden City, in Utah Territory, is situated at the western base of the Wahsatch Mountains, in the Salt Lake Basin. It is between the Ogden and Weber Rivers, and is the point where the Union Pacific, the Central Pacific, and the Utah Central Railroads effect a junction. The town contains about six thousand inhabitants, and is built partly on the terrace that skirts the base of the mountains, and partly on the level bottom through which the rivers flow. Its streets are all wide and lined with beautiful trees, while on each side flows a clear stream of fresh spring-water.

The Wahsatch Range extends north and south, its gray peaks being snow-crowned the greater part of the year. Our first camp after leaving Cheyenne, Wyoming Territory, was on one of the terraces, about a mile from the foot of the mountains, which are cut into sections by numerous cañons. They intersect the range at right angles to the trend. One of them, Ogden Cañon, I visited as typical of the others. The rocks at the mouth of the cañon I found to be syenites of a red color, and having a specific gravity of 2.6. The feldspar in it was a flesh-colored orthoclase alone. The only veins noticeable were some illy defined of quartz and feldspar. These syenites must in places pass into granites, for a specimen brought me I found to be a protogine containing a green talc, which, with the flesh-colored feldspar and white quartz, formed a beautiful specimen. The rock, however, could not be located. In this syenite, at the distance of probably half a mile to the south of Ogden Cañon, some prospecters have claimed to have discovered tin ore. In the specimens brought me I failed to discover even a trace of tin. Upon the syenites very thick beds of quartzites lie. They are mostly of a white color. In some places, however, they are dark-brown, and highly ferruginous. The specific gravity of these quartzites varies from 2.5 to 2.6. They extend for some distance and dip at an angle of about 80°. I found, also, a metamorphic conglomerate, composed of beautiful red and pink siliceous pebbles imbedded in a light-gray siliceous matrix. The quartzites are succeeded by quartz schists, which in turn pass into a dark cherty or siliceous limestone. This limestone produces an excellent quality of lime, which has been used by the Union Pacific Railroad Company in building their engine-houses. There are in the cañon three lime-kilns in active operation.

Farther up the cañon than I was able to go, I was told there was a ledge of silver ore that promises to pay well. A piece of ore that was handed me, and alleged to be from the same, yielded, on examination, both silver and copper. I was also given a piece of coal said to be from some distance up the cañon.

We left Ogden on the morning of June 10, and took up our line of march, traveling in a northwesterly direction along the base of the mountains, around Bear River Bay, and in the afternoon camped in a beautiful, small, green valley, having gone ten miles. Near our camp were situated some hot springs, very noticeable from the abundant,

deep crimson-colored deposit about them. There are a number of springs at the base of a spur of the mountain range which is to the east of them. The average temperature of the water was 129° F., the temperature of the air at the time of observation being 83° F. The highest temperature was found in one of the smaller southern springs, and was 136° F.; while at the distance of 100 feet to the west of it the lowest temperature, 109° F., was found. The principal spring was almost circular in shape, and from 12 to 15 feet in diameter and 5 feet in depth. Its temperature was 128° F. some distance from its edge, although probably higher in the center, beyond the reach of the thermometer. The taste of the water was decidedly bitter and salty. In all of the springs there was at intervals a slight bubbling of carbonic acid gas. At no time during observation, however, was it considerable. No other volatile substances were discovered. The specific gravity of the water was 1019, and an analysis revealed the following constitutents:

Chloride of sodium, (common salt,) very abundant,
Sulphate of lime,
$\left.\begin{array}{l}\text{Magnesia,}\\ \text{Lime,}\\ \text{Iron,}\end{array}\right\}$ as carbonates.

The amount of iron was small, from its having been thrown down by the escape of the carbonic acid gas at the time of examination. A considerable area around the springs is covered with a deposit of iron, the bright-red color of which contrasts well with the green of the surrounding vegetation. In isolated spots, as well as on some of the rocks near the water, there is a white deposit. Between the springs and the lake or bay there extend salt marshes or flats for the distance of three or four miles.

Leaving our camp on the 12th, we resumed our way in an almost northerly direction, until we neared Brigham City, when we turned to the right and entered Box Elder Cañon, another of those gorges cut through the mountains at right angles to its trend. Our way was now upward for eight miles through the cañon—grass-covered hills with here and there projecting rocks rising high on either side of us, while at our feet rushed a swift stream, its banks fringed with elder-bushes. The rocks here are identical with those in Ogden Cañon. In the evening we camped in Box Elder Park, about 500 feet above the level of the Salt Lake, near the Danish settlement of Copenhagen. The park is almost circular in shape, and is about two miles in diameter, encircled by rounded hills composed of dark siliceous limestone. Between this point and Cache Valley, a distance of almost thirteen miles, our road led us now up hill and now down, past masses of dark-blue Carboniferous or mountain limestones, containing white calcite with perfect cleavage. They are fossiliferous. Just before reaching Wellesville, our camping-place, there was a change to calcareous sandstones of a light-gray color. The scene as we emerged from the mountains was grand. Before us lay Cache Valley, dotted with numerous Mormon towns. It is one of the best cultivated districts in Utah, and, clothed in its spring garb, presented a beautiful appearance. It is about fifty-four miles in length and will average about seven miles in width. The rocks in the mountains on either side are limestones and quartzites. Near Mendon there occurs an oolitic limestone, which is much used for building purposes throughout the valley. Our course on the 14th and 15th lay through Cache Valley. At the upper end is the town of Franklin. To the west of the town there is a large, isolated *butte*, the basis of which is a blue limestone containing a percentage of silica. This stands in the middle

of the valley like some monument, the surrounding rock having been washed away. On June 16 we crossed Bear River and found immediately a change in the rocks. Instead of limestone we came across greenstone, among which I obtained specimens of aphanite and melaphyre, the latter amygdaloidal in places. The specific gravity of some of these specimens is as follows: three specimens of dark-green aphanite, 2.5; and two specimens of melaphyre, 3.1. Continuing for about five miles, they are intercepted by quartzites containing a small percentage of lime.

About three miles above the town of Oxford I found some men mining for silver. W. J. Cooper, of Oxford, is the owner of the lode, which is 7 feet wide, and dips west at an angle of about 40°. The strike is north and south. The wall-rock on either side is greenstone. The gangue of the lode is composed of quartz, with calcite and feldspar. Some good crystals of calcite were seen, and also brown spar, (rhomb spar.) The ore is principally chloride, reddish and greenish. A shaft has been commenced, but has reached only the depth of 30 feet.

Six miles above Oxford we entered Marsh Creek, or Round Valley, passing from Utah into Idaho Territory. The entrance to this valley is between two high *buttes*, one consisting of a ferruginous sandstone of a bright-red color on its weathered surfaces, the other composed of a bluish siliceous limestone. Passing through this natural gateway, we were in an old lake basin, the rocks being modern Pliocene sandstones of a white color, all containing some lime. The road soon ascended to the top of a terrace of drift formation, covered with a sparse growth of sage-brush. Leaving this valley the following day, June 18th, we entered the valley of the Port Neuf River. Just before entering the valley we passed over a floor-like layer of dark basaltic rock. We followed the river on its right bank. All along the left bank there is a layer of basaltic rock, its hexagonal columnar form reminding one of the Giant's Causeway. The formation over which our road led us was drift, while the hills on our right presented alternations of limestones and quartzites succeeding each other at short intervals. There seems to have been some point higher up the valley from which the molten mass flowed during the Tertiary period, for the formation on which it rests is Tertiary.

In crevices in the rock in many places I obtained specimens of obsidian. As we neared the mouth of the valley it became wider and wider, and the mountains receded until they spread out into the Snake River Valley.

Emerging into the valley we turned to the right and crossed the hills to Fort Hall, a post that has only recently been established, in Idaho Territory. We arrived there on the 21st of June. The following day I made a visit to some warm springs in Lincoln Valley, about three miles southeast of the fort. I found five springs situated at the head of a depression in the valley, whose direction was east and west. They gush forth from the foot of the hills, the bases of which are limestones. In spring No. 1, which was the warmest, the thermometer recorded 87° F. It was about a foot in diameter, nearly circular, and 9 inches in depth. The next two, No. 2 and No. 3, to the southeast of No. 1, had equal temperatures, each being 77° F. Only one of these was defined as a spring, being 3 feet in diameter and 2 feet in depth. In the other the water merely poured forth from the rocks in a narrow stream. No. 4 and No. 5 were of the same character as the last mentioned, and reached each the temperature of 69° F. They were still more to the east. The water in all was beautifully clear, due to the presence of carbonate of lime. The specific gravity of the water was 1003, and con-

tained carbonate of lime, and alumina probably as a sulphate. There was no perceptible evolution of gas. In the course of the stream there was a deposit of lime, small in quantity, incrusting grass, moss, and twigs.

About a mile east of the fort I found a number of hills, whose bases are fine-grained red sandstones of very free quality. It would make a very good ornamental building-stone. The rocks that succeed and lie upon them are Jurassic limestones, containing an abundance of fossils. We left Fort Hall on the 23d of June, and until the 28th were in the Snake River Valley, a wide plain covered with sand and sage-brush. For ninety miles nothing else was passed over save here and there exposures of dark basaltic rock, which seems to be spread out over the entire plain. At some time, during or since the Tertiary period, the plain must have been flooded with molten lava, which came, in all likelihood, from several points of eruption. As we came down the Port Neuf River we could see in the distance what appeared to be an old crater, and on our way across the Snake River Basin we passed another.

At Eagle Rock we crossed Snake River on Taylor's bridge. The river here has cut a narrow gorge through the rock, forming quite a cañon. The rock rises 10 feet above the level of the water. The current is very swift. The rock shows the hexagonal columns, so characteristic of the cooling of the molten mass. At "Hole-in-the-Rock," on Dry Creek, we had an opportunity of proving that the lava extends over the valley like a crust, for the most part at least simply, and not in the form of dikes. Here we visited a cave, which has been formed by the water flowing beneath the basalt and washing out the sand. The entrance to the cave is formed by a falling in of the crust. Clambering down over the broken fragments, we discovered seven chambers. There were two entrances, one to the northwest and the other to the southeast. In the first-named direction we found three chambers, each about 25 feet in height and 200 feet in diameter, they being almost circular. The chambers are separated from each other by loose, fallen rock. After penetrating as far as possible we retraced our steps, and were about leaving the place, when we discovered an aperture just large enough to admit one at a time, leading toward the southeast. Entering this we found four chambers separated from each other by piles of loose, fallen rock, as in those on the opposite side. Instead of being circular these were oblong in shape, each being about 300 feet in length and 150 feet wide, the height being 20 feet. Each succeeding chamber is somewhat lower than the preceding. The roof is arched and composed of dark basaltic rock. From it there hang innumerable small stalactitic formations, caused by the percolation of the water through the rock. There are also numbers of air-bubbles in the rock, which hang from the roof in drop-like processes, forming points for the formation of stalactites. The bottom of the cave is sandy; and in a hole dug to the depth of 20 feet, it was observed to be distinctly stratified, showing it to have been deposited by water. That this condition extends over the whole valley is further presumable, from the fact that a considerable number of the streams flowing through it sink and are lost to sight. Their disappearance is easily accounted for by their flowing underneath this crust.

On the 28th of June we left the Snake River Basin, and entering Beaver Head Cañon, began to ascend on our way across the main divide of the Rocky Mountains. The igneous rocks were still present. At the mouth of the cañon we passed an isolated hill, composed of schistose, or slaty phonolite, each layer being one-eighth of an inch in thickness

and porphyritic. Its specific gravity is 2.39. On reaching the top of the cañon we encamped in Pleasant Valley, a beautiful little valley set in the mountains like a gem. Its elevation is 6,086 feet. Near our camp was a deep, narrow gorge cut through rock, which, on examination, proved to be a true porphyritic phonolite, having disseminated through it crystals of sanidine, nepheline, and haüynite. The rock is of a dark-gray color, very compact, having a specific gravity of 2.75; the crystals occurring in spots, occupying about a quarter of an inch each, and from one to two inches apart. The haüynite occurs as reddish, octagonal crystals. The nepheline is the variety sommite, and is in small grains; while the sanidine, or orthoclase, is in tabular crystals. I insert here the mineralogical composition of some phonolites of Bohemia, given by G. Jenzsch:

	Per cent.
Sanidine, estimated at	53.55
Nepheline, estimated at	31.76
Hornblende, (arvendsonite)	9.34
Titanite	3.67
Pyrites	0.04

I shall take the earliest opportunity of making a chemical analysis of this rock. The occurrence of these phonolites would go far toward proving the age of the eruption, even though we had not the Tertiary formations beneath it, for no true phonolite has been found to be of other than Tertiary or still more recent origin. The following day we continued on our way across the mountains, passing over the divide, the elevation of which was 7,044 feet. The more modern rocks were conglomerates, presenting little or no interest. I obtained some specimens of trachyte, which are vesicular, of a white color, having a reddish tinge in some parts. I also obtained specimens of a vesicular rock, which I consider to be a phonolite, although I had not the opportunity of observing it in position. One of the specimens was of a dark-gray color, having a specific gravity of 2.57. The specific gravity of the light varieties was 2.3. After crossing the divide our way lay over Pliocene formations, in which I obtained a white sandstone composed of very fine pebbles, cemented by a calcareous matrix. The older rocks were limestone conglomerates, upon which rested white and red sandstones.

The 30th of June we spent in camp, visiting a peak near us where we found the limestone conglomerates at the base with sandstones on top. The next day our route was through a rolling country, now passing over a hill and now through the valley of a small stream. I procured specimens of a very compact, dark phonolite, having a specific gravity of 2.4. The recent rocks were of Pliocene origin. Some of them consist of very small, bluish, siliceous pebbles in a white, siliceous matrix. Upon these were grayish calcareous sandstones, also Pliocene. They consist of minute red and black pebbles cemented by lime. On top of these were yellowish calcareous marls. We camped at night at an elevation of 6,988 feet, in the midst of gneissic hills, which become granitoid in places. The following morning we entered Wild Cat Cañon, a picturesque, gorge-like valley, the rocks of which stand out boldly on either side. At the head of the cañon I found a vein of coarse granite, containing labradorite in good cleavable masses. In some of the specimens the play of colors was particularly fine. There were also some good crystals of black mica, (biotite.) The surrounding rocks were fine-grained granites of a reddish hue. On top of the granites were

quartz porphyries, or elvanite, which passed into felstone, or petrosilex. In some places there appeared to be a dike running through the granite. The elvanite I found of two varieties, one having a gray-colored matrix with feldspar crystals of a pink tinge, and the other having a red matrix with white crystals disseminated through it. The petrosilex, or felstone, was of various shades, blue, gray, yellow, and red, predominating. The yellow variety has a specific gravity of 2.01; the blue, 2.53; and the gray, 2.72. These rocks seem to pass into gneiss, which itself at some distance becomes granitoid, thus proving them to be of the same composition as granite, only in a more compact state, having been forced through the granite and therefore of later origin.

We camped in the evening of the 2d of July on Black-Tail Deer Creek. Leaving here the following morning, the first part of our course led us up over hills that were once the bottom of some large lake. Reaching the top, a grand view burst on our sight. We stood on the rim of a vast amphitheater. At its bottom, far beneath us, was a green line marking the course of a stream, one of the branches of the Stinking Water River. The rounded hills converged toward the stream, while here and there, on their sides, were projecting strata of white Pliocene sandstones, contrasting well with the grassy slopes. On the top, even underneath our feet, was a capping of black basaltic rock, which on some sides projected over the edge. So regular was it that it seemed as though it had been laid with mathematical accuracy. The background completing this picture was composed of sharp peaks and hills, with a blue, snowy range in the extreme distance. We now began to descend, proceeding down the cañon, which is named the Devil's Pathway. Our road led us between masses of gneissic and granitoid rocks. Here again we found dikes of elvanite, quartz-porphyries, and felstones, some of beautiful colors, red, blue, gray, and violet. I obtained a striped or slaty porphyry, looking very much like riband jasper.

Emerging from the rocky walls we pitched our tents on the bank of the Passamaria, or Stinking Water River. The next day we again passed over modern formations in an old lake basin until within some ten miles of Virginia City, when we came across quartzose rocks mostly auriferous. Here we found the first evidences of mining. Near the road a man by name David Lloyd was industriously washing out the gravel from the side of a foot-hill. He informed me that he was averaging about $3 per day.

Passing between quartzose and gneissic hills containing veins of garnetiferous hornblende schist we soon began to ascend, and crossing the hills, passed through Nevada, a small mining town below Virginia City. All about us were the evidences of mining in the heaps of bare pebbles, numerous water-courses, and upturned barrows. It being the anniversary of our national independence, all were idle save a few Chinamen.

Virginia City is situated in Madison County, in the southern part of Montana, and is one of the chief mining centers of the Territory. It is on Alder Gulch, one of the tributaries of the Stinking Water, or Passamaria River. The mines about Virginia City are principally placer-diggings. Gold was discovered on Alder Gulch in 1863, being the second discovery in the Territory; the placer-diggings of Bannack having been discovered in 1862. Since that time enormous quantities of gold have been taken out, although it is impossible to say exactly how much, as the estimates are conflicting.

Alder Gulch is about sixteen miles long, and has a number of tributaries, all of which contain gold. Bald Mountain stands at the head of the gulch. Near it the gold is coarse, and the farther we go from it

down the gulch the finer it becomes. The width of the gulch will average about 200 feet, and the hills on either side are rounded. The country rock is gneiss, presenting the same characteristics as that I have before noticed, being in many places garnetiferous. The gravel is washed through a flume and the gold caught at various parts of its length. One of the greatest wants for the successful prosecution of mining here is a water-supply. There are a number of quartz-mines about Virginia City, but all unite in saying that more capital is needed to make them pay well. I was shown specimens of argentiferous galena and of copper ore, which will no doubt one day add much to the prosperity of Montana. The copper, I was told, was being mined and sent to California to be smelted. In Alder Gulch I obtained good specimens of garnets and precious serpentine.

We left Virginia City on the 6th of July, and crossed the hills to the Madison River, traveling in a northerly direction. We passed over dark igneous rocks, which were in contact with coarse ferruginous sandstones. We followed the river until its passage through a narrow cañon necessitated our turning from it and crossing the mountains. Soon after leaving the river we crossed Meadow Creek, which flows through an exceedingly beautiful and fertile valley. We now began to ascend rapidly, and passed by three deserted shafts sunk in the granite beds. Besides granites there are here quartzites and gneiss. Soon after crossing the summit, we encamped in the Hot Spring district. Near our camp were some hot springs, which, however, presented but little of interest. The highest temperature was 76° F., and the lowest 64° F.; the temperature of the air being 48° F. The largest spring was only about a foot and a half in diameter, and four inches in depth. The rock at whose base they have their origin is a reddish syenite. A few miles farther on we passed some larger springs, situated close to the road. Their size was about 4 feet by 10 feet. The highest temperature here was 124° F., and the lowest 110° F.; the atmosphere at the time of observation being 50° F. They were filled with *Confervoidea*. We passed by a number of mills all working, being supplied with the gold ore from quartz-mines in the neighborhood. One of these mines, the Red Bluff lode, I visited. The lode, which is owned by J. J. Lown, dips to the north, the strike being east and west. Its width varies from 2 feet to 7 feet. The country rock is mainly gneiss. The hanging wall is a gray granite, and its foot-wall gneiss. There are two shafts 100 feet apart, the first one reaching the depth of 105 feet, and the second 110 feet. They are connected by a passage, which extends 45 feet beyond the second shaft, getting below the water-level. The ore is principally a red jasper, with the particles of metallic gold disseminated through it and plainly visible. Below this jaspery ore there are galena and pyrites. I also obtained some beautiful pieces of blue chalcedony and some semiopal, the latter being almost all dendritic. Approaching the hanging wall the ore passed into a porphyritic rock, with large masses of bright-red jasper. The mine had been worked for six months, and in that time had averaged $60 to the ton. There were about eight men employed, at the rate of $3 each per day. Leaving here, a ride of a few miles brought us, a second time, to the Madison River, which having cut its way through the mountains, here spreads out and flows smoothly between low rounded hills, from whose grassy slopes ridges of gneiss and hornblende schist project. On examination these latter proved to be garnetiferous. Following the Madison but a short distance, we turned to the right and crossed the hills to the valley of the Gallatin River. This is the garden valley of Montana. It will average fifteen miles in width,

and is about sixty miles long. It is well watered by the branches of the Gallatin River, which are extensively used in irrigation. The hills are covered with excellent grass, and form one of the best grazing grounds in the world. Quite a considerable part of the valley is already under cultivation. Crossing the Gallatin, we soon arrived at Bozeman City, a flourishing town, destined to be of considerable importance should the Northern Pacific Railroad run through it. Three miles beyond the town we pitched our tents at Fort Ellis. Fort Ellis is situated on the eastern side of the Gallatin Valley, on the east branch of the Gallatin River, and has a force of four companies of cavalry and one company of infantry, under the command of Major E. M. Baker. On the 11th of July we visited a small lake twelve miles southeast of the fort. After a ride over a trail which led through dense timber, making our progress difficult, we reached the lake, a beautiful sheet of water ensconsed in the midst of hills which rise to a considerable height around it. It is about half a mile in width, and the stream flowing from it forces its way in a deep gully through quartzites. It falls about 500 feet in a quarter of a mile. It rushes along with furious rapidity, leaving high projections of rock on either side. The lake shore is bordered with limestones, which rest on the quartzites. Having refitted and obtained an escort, we left Fort Ellis on the 15th, and, after a ride of but nine miles over a very rough road, went into camp. During the day we passed over fossiliferous sandstones of Tertiary origin. At the head of Spring Cañon, through which a small stream flows to join the Gallatin, we passed an old coal-mine. It is abandoned, and being full of water prevented our entrance. The shaft, however, does not penetrate very far. The coal is lignite, similar to that found along the Union Pacific Railroad. On top of the sandstones we again had igneous rocks, (dark basalts.) For the two following days we were obliged to travel very slowly, having to build our road in many places. The sandstones and basalts continued until we reached the valley of the Yellowstone River, which we entered on the morning of the 17th. The flow of the lava has spread out over the valley, forming a floor, over which our road led. I obtained on our way chips of chalcedony and obsidian, which were abundantly scattered over the valley.

The valley of the Yellowstone, at the point we entered it, is about four miles wide, and has on its eastern margin a grand mountain range, whose sharp peaks proclaim its volcanic origin. The river is easily traced by the line of timber on its banks. At Botteler's Ranch we formed our permanent camp, being unable to take our wagons farther, and made preparations to pursue our way with pack-mules. On the 20th of July we left Botteler's, stringing out in single file, with our pack-train along the trail up the Yellowstone River. The trail led us along the left bank of the river over igneous rock, the most conspicuous of which was a breccia composed of large masses of black material imbedded in a red matrix. After a ride of about fifteen miles we reached the lower cañon. Here the river breaks through masses of gneissic rock, which rise abruptly from the water's edge, and over which our trail was very steep and rocky. The cañon is about three-quarters of a mile in length and about 280 feet wide. At the bottom of this ravine the river, of an emerald tint, rushes over the rocks, whose resistance causes it to be thrown into numerous foam-capped ripples. The gneissic rocks are for the most part garnetiferous, though somewhat indistinctly so. They pass in many places into hornblende schists, and in others become granitoid. Emerging from the cañon, our way led us alternately over low hills of igneous origin and expanded valleys. The soil seems to be

made of the finely pulverized dust of volcanic rock, and is covered with a sparse growth of sage-brush. The river is bordered with a growth of thinly scattered pines and quaking-asps. In the mountains, on either side, are stratified limestones, which rest on the gneissoid rocks we observed in the cañon. Scattered over the hills and through the valleys I found many beautiful specimens of chalcedony and chips of obsidian. Many of the chalcedonies were geodes, in which were crystals of quartz; others contain opal in the center and agate on the exterior; and still others have on the outside attached crystals of calcite. A short distance above the cañon we came to Cinnabar Mountain, so named from the color of some of its rocks, which have been mistaken for cinnabar, although the red color is due to iron. Here we encountered what is called the Devil's Slide. It consists of two masses of rock in almost vertical position, perfectly defined as two walls. They are about 50 feet in width each, and 300 feet high, reaching from the top of the mountain to its base. They are separated from each other about 150 feet, the intervening softer material having in the lapse of time been washed away. The right-hand mass is a whitish quartzite, while the left-hand one is a dike of greenish porphyritic trachyte in which the crystals of feldspar are thickly disseminated. Parallel with these two principal walls are many more ridges of quartzitic and slaty nature, none of which equal them in magnitude. They are all nearly at right angles to the strata of limestone, which lie on either side. In a space to the right of the main ridge there is a broad red band reaching from the top to the bottom of the mountain. It is caused by the sliding of ferruginous limestone and clay. It is about 20 feet wide and distinctly outlined. These ridges must have been forced into their present position when the strata above were horizontal. That there has been a terrible convulsion here in the past is proved a few miles farther on, where the strata of limestone are so contorted that, within the space of 200 feet, they dip in three different directions. In the limestone there was an abundance of crystals of calcite. Some eight or ten miles farther on we reached Gardiner's River, a stream emptying into the Yellowstone just as the latter emerges from a cañon. Here we left the Yellowstone to visit some hot springs about four miles above the junction of the two streams. We soon came to the evidences of hot springs in the calcareous deposit, beneath which the warm water escaped into the river. Passing a number of hot springs, we began the ascent of a steep hill, passing over the deposit, which gave forth a hollow sound beneath our horses' feet. Suddenly we came in full sight of the springs. We were totally unprepared to find them so beautiful and extensive. Before us lay a high white hill, composed of calcareous sediment deposited from numerous hot springs. The whole mass looked like some grand cascade that had been suddenly arrested in its descent, and frozen. On examination we found that the deposit extended for some two miles farther up the gorge, and below reached to the edge of the river, occupying altogether about three square miles, although the greater part of it is now in ruins and overgrown with pines. Still the outlines can be very distinctly traced. The principal mass is arranged in a series of terraces, one above the other, each being composed of beautiful basins, semicircular in shape, and having regular edges, with exquisitely scalloped margins. Their size varies, but will average 5 by 8 feet. They are filled with water of different temperatures, from cold to the boiling-point. The color of the sediment is for the most part white, although here and there are tinges of yellow where sulphur predominates, and red and pink where there is iron. The weathering of those parts

in which the springs are long extinct has caused it to assume a grayish appearance. The main springs are situated on a terrace about half way up the mountain, and cover an almost circular space of about two hundred yards in diameter. The color of the water here is almost indescribable, being the purest azure. From these springs clouds of steam are always rising, and the water is always bubbling and seething in its vast caldron-like basin. The water flowing thence proceeds downward from terrace to terrace, until it reaches the lowest, considerbly cooled. The springs in the center of the main basin are probably all at the boiling-point, although we were unable to determine their temperatures as they were beyond our reach. The temperature of the hottest we were able to determine was 162° F. The terrace immediately above the main basin is bordered by a long rounded ridge, with a fissure extending its whole length. From this fissure nothing but hot vapors and steam escape. Its interior is lined with beautiful crystals of pure sulphur. The bubbling and gurgling of the water far beneath could be distinctly heard. Back of this ridge were two small geyser-like jets of water, which rose to the height of 3 feet intermittently. Farther up the gorge, about 1,000 feet above the level of the river, we discovered two mound-like formations, the largest of which was about 20 feet in height and 50 feet long by 30 feet wide. The other was only about 5 feet high. From the top of these the water spouted to the height of 4 or 5 feet, each geyser-spout proceeding from a small conical mound about a foot in height and eight inches in diameter at its base. Breaking one of these cones, the tube through which the water came was found to be very small, only about a quarter of an inch in diameter, while the remainder of the cone was composed of layer upon layer of sediment deposited by the overflowing water. Near these mounds there is a sulphur-spring emitting a considerable quantity of sulphureted hydrogen. On the lower terrace the water has spread out more and formed shallower basins. Here there are also some remarkable formations, high, chimney-like masses of the sediment, composed of layer upon layer, which, in the lapse of time, has become very hard. One of the most curious of these, the Liberty Cap, named from its shape, is about 45 feet high and 15 feet thick. It is altogether likely that these have once been veritable spouting geysers, for they are analogous in structure to the smaller active ones found higher up the valley. They became so high, however, that the pressure of the column of water was too great for the boiling-point to be attained in the depths below. Then the eruptions ceased, and the spring gradually became extinct, leaving these masses stand as monuments of their former power.

The temperature of the water near the river is 120° F.; in some springs a little higher up, 130° F.; and on the lower terrace, 155° F. Still a little higher there is a boiling spring, 162° F. On the second terrace the temperature varies from 142° F. to 162° F. On the third or main terrace it is from 155° F. to 162° F., and on the next, where the small geysers are, it is from 156° F. to 162° F. At the two mounds high up the valley it is from 142° F. to 143° F., while in the sulphur spring near them it is only 112° F. The average temperature of the atmosphere was 63° F. The majority of the springs give off sulphureted hydrogen gas, some being more strongly impregnated than others. The water contains sulphureted hydrogen, sulphate of magnesia, and carbonates of lime, soda, and potassa. Whence do these springs obtain the lime which is so abundant in their composition? I think from the passage of the water through the strata of limestone. Even the igneous

rocks, which are mostly porphyritic trachytes of a light-gray color, contain a considerable percentage of lime, and some of the pieces I obtained were coated with crystals of calcite. To the west of the hills there are high volcanic peaks on the summits of the hills, whose elevation is considerable. To the east, bordering Gardiner's River, there is a remarkable wall, composed of limestones and sandstones, capped with a layer of basalt. Indeed, the whole valley is shut in by high hills. In New Zealand there is a hot-spring formation which resembles this very much in appearance, although the constitution of the sediment is different. In New Zealand silica predominates; here carbonate of lime appears in the greatest quantity. The white deposit contains—

Carbonate of lime,
Chloride of calcium,
Carbonate of magnesia,
Carbonate of strontia,
Carbonate of soda,
Carbonate of potassa,
Sulphate of magnesia,
Sulphur,
Silica.

I insert Hochstetter's description of the New Zealand formation, to show how similar it is in appearance:

"First of all is Te Tarata (signifying tatooed rock) at the northeast end of the lake, (Rotomahana,) with its terraced marble steps projecting into the lake, the most marvelous of the Rotomahana marvels. About 80 feet above the lake, on the fern-clad slope of a hill, from which in various places hot vapors are escaping, there lies the immense boiling caldron in a crater-like excavation with steep, reddish sides 30 to 40 feet high, and open only on the lake side toward the west. The basin of the spring is about 80 feet long and 60 wide, and filled to the brim with perfectly clear, transparent water, which in the snow-white incrusted basin appears of a beautiful color like the blue turquois. At the margin of the basin I found a temperature of 183° F., but in the middle, where the water is in a constant state of ebullition to the height of several feet, it probably reaches the boiling-point. Immense clouds of steam, reflecting the beautiful blue of the basin, curl up, generally obstructing the view of the whole surface of water; but the noise of boiling and seething is always distinctly audible. The reaction of the water is neutral; it has a slight salty, but by no means unpleasant taste, and possesses in a high degree petrifying, or rather incrusting qualities. The deposit of the water is like that of the Iceland springs, siliceous, not calcareous, and the siliceous deposits and incrustations of the constantly overflowing water have formed on the slope of the hill a system of terraces, which, as white as if cut from marble, present an aspect which no description or illustration is able to represent. It has the appearance of a cataract plunging over natural shelves, which, as it falls, is suddenly turned into stone.

"The siliceous deposits cover an area of about three acres of land. For the formation of those terraces, such as we see them to-day, doubtless thousands of years were required. Forbes, judging by the thickness of the siliceous deposits on the great geyser of Iceland, which he estimates at 762 inches, and by the observation that an object exposed to the discharge of the geyser-water for the space of twenty-four hours is covered with a sheet of paper thickness, has calculated the approxi-

mate age of the great geyser at one thousand and thirty-six years. Similar calculations might be made also with regard to the Tetarata fountain by examining the thickness of the siliceous incrustations.

"The flat, spreading foot of the terraces extends far into the lake. There the terraces commence with low shelves containing shallow water-basins. The farther up, the higher grow the terraces; two, three, also some four and six feet high. They are formed by a number of semicircular stages, of which, however, not two are of the same height. Each of these stages has a small raised margin, from which slender stalactites are hanging down upon the lower stage; and encircles on its platform one or more basins resplendent with the most beautiful blue water. These small water-basins represent as many natural bathing-basins, which the most refined luxury could not have prepared in a more splendid and commodious style. The basins can be chosen shallow or deep, large or small, and of every variety of temperature, as the basins upon the higher stages, nearer to the main basin, contain warmer water than those upon the lower ones. Some of the basins are so large and so deep that one can easily swim about in them. In ascending the steps, it is, of course, necessary to wade in the tepid water, which spreads beside the lower basins upon the platform of the stages, but rarely reaching above the ankle. During violent water-eruptions from the main basin, steaming cascades may occur; at ordinary times but very little water ripples over the terraces; and only the principal discharge on the south side forms a hot, steaming fall. After reaching the highest terrace there is an extensive platform, with a number of basins, 5 to 6 feet deep, their water showing a temperature of 90° F. to 110° F. In the middle of this platform, there arises, close to the brink of the main basin, a kind of rock island, about twelve feet high, decked with manuka, mosses, lycopodium, and fern. It may be visited without danger, and from it the curious traveler has a fair and full view into the blue, boiling, and steaming caldron. Such is the famous Tetarata."

The above is an almost perfect description of the springs at Gardiner's River. We have the same beautifully clear blue water; the terraces and basins even to the stalactitic processes hanging from the latter. We have also an upper platform or basin with the main springs, from which continual clouds of steam are rising. The lower terraces are also shallower and their basins filled with cooler water. We have the same form of natural bathing-basins of a pure white color. To these latter some of our party gave the names of Jupiter's baths and Diana's pools. The differences are these: in New Zealand the deposit is mainly siliceous, here it is calcareous; in New Zealand the water is neutral, here it is alkaline; in New Zealand the main spring is probably a vast geyser. At Gardiner's River it is not likely, at the present time at least, that it is a geyser, for the main springs are so large that even if there is a tube at the base supplying one of the conditions for a geyser the pressure of the water would prevent any eruption unless it should take place at extremely long intervals. If so, the display would be grand beyond all precedent. It is likely, however, that some time in the past it has fulfilled all the conditions of a geyser. The deposit at Gardiner's River is much more extensive than that of the Tetarata.

We left the hot springs on the 24th of July. Proceeding down the hill we crossed the two branches of Gardiner's River and wound our way up the right bank of the east fork of the river. Our course was along the steep side of the mountain, over sandstones, which were capped with a broad plateau of basalt, fragments of which were strewn along our trail. After about four miles of steady climbing we reached the top

of the valley. Here the basaltic layer extends across the gorge, forming an abrupt perpendicular wall, broken only on the side opposite that on which we were. Here the water rushes down in a beautiful fall, its beauty half-hidden by the dense foliage of the pines which surround it. Ascending upon the basaltic platform, and looking back, the scene was grand. High mountains in all directions, their rounded forms relieved by numerous sharp peaks, formed the background, while in the foreground beneath us lay the valley through which we had come. The central feature of the whole scene was the hot-spring formation, its pure white color contrasting strongly with the green of the surrounding vegetation. Turning again, the scene in front was different. Although there was less of grandeur there was more of beauty. Before us lay low, rolling hills clad in bright verdure and dotted with scattered groups of pines. About a mile farther on we passed a second cascade. The water flows down a bed of basalt, which is inclined at an angle of about 45°, arranged in a series of ledges reaching from the top to the bottom, a distance of about 200 feet. These ledges cause the water to be broken into foam, giving it at a distance, the appearance of a mass of snow. Bordering the cascade are chimney-like masses of red igneous rock. The horizontal and vertical fissures in it make the resemblance to masonry very striking. Near here we obtained some good specimens of silicified wood.

The following day we reached the Yellowstone River at the junction of its two forks. Here we encountered gneissic rocks, and scattered over the valley were numerous granitic bowlders, their rounded form plainly indicating that they must have been carried some distance before being deposited in their present position. Above the junction of the two forks the main branch of the river emerges from a cañon, which is over 500 feet in depth, its walls being almost perpendicular. The walls have a capping of basalt, the columnar form of which is very distinct, especially at Column Rock, near the mouth of Tower Creek. Tower Creek is a swift mountain torrent, which, after rushing through a narrow gorge, with steep and often precipitous sides, suddenly dashes over a ledge of rock, and falls perpendicularly a distance of 156 feet into a rounded basin which the water has cut out of the solid limestone. The width of the fall is about 20 feet. Reaching the bottom the water hurries on through a short cañon to the Yellowstone River. Upon the limestones rest volcanic rocks, trachytic in nature. These have been so eroded by the action of the torrent as to leave tower-like masses 100 feet in height, standing isolated on the edge of the creek. Two of these columns stand, one on either side of the fall, at its edge. They are yellowish in color from the presence of sulphur, and the exposure to the weather has rendered them very friable. The bank of the Yellowstone, immediately opposite the mouth of Tower Creek, is about 600 feet high and has two rows of basaltic columns, each one of which is about 25 feet in height and 5 feet in diameter. Between these two layers, which are 200 feet apart, are beds which seem to have a large amount of sulphur in their composition from their bright-yellow color. We were not able, however, to cross the river to determine it. There are also, doubtless, numbers of hot springs scattered along the edge of the river on that side. A few yards above the mouth of Tower Creek, on a small stream emptying into the Yellowstone River, there was a hot spring and a number of vent-holes giving off sulphureted and carbureted hydrogen. The main spring is only 2 feet in diameter and about 18 inches deep. It is close to the edge of the creek and gives off sulphureted and carbureted hydrogen. The basin of the spring is a black, clayey material.

Its temperature was 127° F. The water was acid in reaction, and contains—

Sulphate of iron and alumina, (abundant,)
Sulphate of magnesia,
Sulphate of lime,
Chloride of calcium,
Oxide of iron,
Free sulphur,
Soda and potassa, (trace.)

There is in the ravine in which the creek is situated a deposit of sulphur, and also near the spring a deposit, white in color, containing—

Sulphur,
Iron,
Alumina,
Silica.

In the bed of the stream there is an abundant deposit of sulphur and also a black carbonaceous material. The sulphurous odors emanating from the ravine are so strong as to be recognized at a considerable distance from it. A short distance above Tower Creek we ascended a peak called Mount Washburne, whose summit is composed of a light-gray trachytic rock containing acicular crystals of hornblende. On the sides of the mountain we found large pieces of chalcedony and agate. Near the base of the mountain there are situated quite a number of sulphur and mud springs. A specimen from one of the latter was of an almost black color, and when dry was covered with a white efflorescence. It contained—

Sulphate of alumina and iron,
Sulphate of magnesia,
Sulphide of calcium,
Sulphur,
Silica.

Our next camp was near the Great Fall of the Yellowstone. It is at the head of the Grand Cañon, a gorge averaging about a thousand feet in depth, which the water has cut through the volcanic rocks. These rocks are mostly trachytes of a white or gray color, on top of which there is a layer that is basaltic in its character. In many places they become rhyolitic, and contain crystals of sanidine, very abundantly distributed through them. In one place I found a perlite-like trachyte porphyry, containing small feldspathic balls (spherulites) with a radiated fibrous structure, mixed with small pieces of obsidian. Some of the rocks are colored by iron, which has been deposited from hot springs. In other places there is an infiltration of sulphur, which gives them a bright-yellow color. There are still some warm springs on the edge of the river, and, at the only place we were able to get to it, there were three or four small springs giving off carbonic acid gas, which has caused an abundant deposit of sesquioxide of iron about them. Having no thermometer with us, we were unable to determine the temperature of the water; but it could not have been much over 90°. It contained a white organic material. Passing the upper fall, after a ride of about eighteen miles, we reached Crater Hills. These consist principally of two conical hills about 150 feet in height. There are several other hills which are smaller. They are all made up in part of hot-spring deposit and a white trachytic tufa. All about the hills there is an extensive deposit, mostly siliceous, forming a crust which often breaks through while walking over it. It is lined with beautiful crystals of sulphur.

At the base of the hills there is a large boiling sulphur-spring, in which the water is constantly agitated, rising to the height of 3 and 4 feet. It is about 12 feet in diameter and encircled by a collar-like rim, which is beautifully incrusted. It consists principally of silica and sulphur. In the stream proceeding from the spring there is quite a deposit of sulphur. The water contains—

Sulphur, (very abundant,)
Alumina,
Silica,
Lime, (trace,)
Iron, (trace,)
Chlorine,
Sulphuric acid.

Its temperature is 183½° F. About 300 feet west of this spring there is a steam-jet, which was named the Locomotive Jet from the noise made by the steam in escaping. The temperature there was 191° F. On the sides of the hills there were many more steam-jets, in which the highest temperature attained was 197½° F. To the southeast of the boiling sulphur-spring is a large turbid spring about 35 feet in diameter. Its contents consisted of a very thin bluish mud containing—

Sulphate of alumina of iron,
Chloride of magnesium,
Sulphate of alumina,
Free sulphur,
Silica,

and having a temperature of 163° F. It was acid in reaction and tasted strongly of alum. About three hundred yards south from the main spring there is a collection of mud and sulphur springs. The principal mud-spring in this group contains a thick, blue mud. It has the consistency of paint, and the steam, in escaping from it, does so with a thud-like noise, and at times projects the mud to a considerable height. Its temperature is 188½° F. The mud has a strong alum taste, is acid in reaction, and contains—

Sulphate of iron and alumina,
Sulphate of magnesia,
Chloride of magnesium,
Alumina,
Sulphur.

Near this latter spring there is another, which was named the Foam Spring. The water is very turbid and, floating on its surface, there is a greenish, sandy, foam-like material consisting of—

Sulphur, (very abundant,)
Silica,
Oxide of calcium,
Sulphate of alumina.

It is in a constant state of agitation. There are many other sulphur and mud-springs here, which resemble one another closely. All the mud-springs are impregnated with alum, and the stream flowing away from the hills is called Alum Creek, the water of which is strongly astringent. The alum is an iron alum. Leaving the hills we found camp, situated on the bank of the Yellowstone River, at a place called Mud Volcanoes. Here again was a large collection of mud and sulphur springs. Immediately back of camp were two crater-like mud-springs or volcanoes about 10 feet in depth, at the bottom of which the escaping steam kept

the thick, blue mud in a state of violent agitation, sometimes throwing it to the height of 15 or 20 feet. This mud contained—

Sulphate of iron and alumina,
Sulphate of magnesia,
Chloride of magnesium,
Alumina,
Sulphur,
Silica.

Near these mud-craters there were also some alum-pools containing alum and sulphur. On the edges of these pools there were a number of holes, from which there was a bubbling of water that flowed into the springs. Upon ascending the hill, at whose base these springs were situated, we could see immense volumes of steam rising toward the southeast. Proceeding in that direction about 400 yards we came to a sort of a cave in a sandstone rock. The entrance is about 15 feet high, and it gradually slopes inward for about 20 feet. At this point, at regular intervals of a few seconds, there bursts forth a mass of steam, with a pulsation which shakes the ground, while a stream of clear water flows from the mouth of the cavern. Its temperature was 184° F. The water had a very faint alum taste, and gave off a slight odor of sulphureted hydrogen. This spring we named the Grotto. A little farther on, after passing a large muddy sulphur pool of about 20 feet in diameter, we found on the side of the hill a huge mud-crater. Its orifice is circular and from it there escapes a dense volume of steam, obscuring for the greater part of the time the view of the boiling mass of mud, which is 20 feet below the surface. It was too deep for us to determine its temperature. The mud seems to be very thin and of a blackish color. Some of the mud from the rim of the crater contains alumina and silica, with a little iron, lime, soda, and potassa. It is probably a true mud-geyser, for the appearance of the crater and the trees around it would indicate that at times it ejects its contents to a considerable height. The trees within 200 feet of it are coated with dried mud even to their topmost branches. During our stay, however, it had no eruption. About three hundred yards southeast of this crater we discovered another muddy geyser. The basin of this geyser was about 50 feet in diameter, and situated in a basin circular in shape, containing two other springs. Its temperature was 191° F. The trapper who was with us, and who had visited the place before, assured us that about 6 o'clock p. m. it would commence spouting. We waited somewhat incredulously, for the spring was quite placid. Soon, however, there began a slight bubbling in the center, and the water began to rise gradually in the basin until suddenly it was thrown into violent agitation, the contents becoming very muddy. Immense volumes of steam escaped, throwing the water to the height of 20 feet. The eruption lasted about a quarter of an hour, when it ceased as suddenly as it began, and the surface of the water was more placid than before. This eruption took place eight times in twenty-six hours. These salses, or mud-volcanoes, are known to all volcanic regions. They are found in South America, in Italy, in Java, in New Zealand, and in Iceland. We found them always where the water was obliged to pass through a bed of clay. In the last group I have described, in one case, that of the "Grotto," the water came through sandstone and was perfectly transparent and clear. Had it been situated in a bed of clay it would probably have been a mud-spring. In all of these we found sulphureted hydrogen gas to a greater or less degree, and they were all impregnated with alum. The sulphureted hydrogen is probably decomposed, losing its hydrogen. The sulphur, becoming

oxidized, unites with the iron and alumina found in the clay and forms the sulphate of alumina and iron. There were, also, in this group a number of springs that were extinct. Between the active springs, in which the mud was very thin, and those which were extinct, nothing remaining save the hardened clay, there were springs of every grade as considered in reference to the consistency of their contents. The water, in the lapse of time, becomes less and less, either by finding new channels, or more likely by evaporation; the mud becomes thicker and thicker until finally all the water disappears, leaving merely vents through which steam escapes; and after a while even these become extinct, and the orifices become clogged up with detritus. All hot springs and salses are the evidence of languishing volcanic action.

We reached Yellowstone Lake on the 28th of July, and on the 31st a small party of us left the lake to visit the geyser region of the Fire-Hole River, the head-water of the Madison. The remainder of the party were to move camp some twenty-eight miles farther to the south, where we would join them in about a week. After a hard day's travel of thirty-one miles through heavy timber we reached the head-waters of the east fork of the Madison, or Fire-Hole River. The mountain range over which we passed was igneous, and in many places masses of pure obsidian were observed. We passed by a number of fumeroles, from which steam and gas were escaping, while all about them was the white siliceous deposit, mingled with sulphur and iron, indicating the past existence of hot springs. The water in the stream on whose bank we were encamped was quite warm, although in the morning the mercury in the open air was down almost to the freezing-point. About a mile and a half from our camp were some hot springs, covering an area of about 200 square yards. Their temperature varied from 128° F. to 199° F. The deposit of some of the springs was calcareous.

Leaving here we proceeded down stream, passing a number of hot springs, some of which were noticeable from the iron deposited in their basins. Their temperatures were from 142° F. to 192° F. The iron was depostied on an organic material, which was abundant in springs of low temperature. Just before going into camp we passed four hot springs of considerable size. They were each situated in the center of a slightly elevated mound, which sloped gradually from the edge of the spring until lost in the general level. The first was 4 feet in diameter, having a temperature of 162° F. The second was 2 feet in diameter, its temperature being 170° F. The third was only about a foot in width and reached 174° F. The fourth and largest was somewhat irregular in shape, being about 15 feet in length and 5 feet in width, the thermometer here recording 156° F. A short distance from these springs was a small mud-spring about a foot in diameter. At the bottom of it, about a foot from the surface, was an agitated mass of thick, bluish mud, having a temperature of 190° F.

Our camp, on the evening of August 1, was on the right bank of the east fork of the Madison or Fire-Hole River, in the lower geyser basin of the Fire-Hole. We divide the springs and geysers of this basin into seven principal groups for the purpose of description. Immediately opposite our camp along the river, occupying a space about a quarter of a mile wide and nearly two miles long, was the first group. Here we recorded the temperatures of sixty-seven springs. The lowest was 106° F., the highest 198° F., and the average 159° F., more than one-half being above 160° F. The temperature of the air was about 50° F. Some of these were geysers, with small tubular orifices, projecting the water from 2 to 5 feet. There were also some large tranquil springs or

cisterns, with beautifully incrusted siliceous basins, containing water whose tint was an exquisite blue. One of these, whose basin was incrusted with successive ridges, along each of which there was a line of the colors of the spectrum, we called the Prismatic Spring. The majority of them were simply siliceous springs. A few, however, were chalybeate. The siliceous sinter, (geyserite,) which was very abundant, contained a trace of lime, iron, and magnesia. In some of the springs of low temperature there was a leathery-like organic material of a red color. The following day we moved our camp nearer the center of the basin, about two and a half miles farther south. On our way we passed between two conical, isolated, trachytic hills. The space between our two camps is filled for the most part by the sinter, and where there is none the ground is marshy. A small stream flowed past our camp conveying the water from the springs to the river. Immediately in front of our camp, about eight hundred yards distant, was the second group, composed principally of geysers. They occupied an area of about three-quarters of a mile. We recorded here the temperatures of sixteen springs, one-half of which were over 190° F. The lowest was 140° F., and the highest 196° F., the average being 183° F. The temperature of the air was about 55° F. to 60° F. One of the geysers, from the peculiar noise it made, was called the Thud Geyser. There were many of them that threw the water from 5 to 10 feet high. In the cool, frosty morning the basin resembled some manufacturing center, as clouds of steam could be seen in all directions. The principal geyser of this group was situated on the slope of a small hill, and was about 20 feet in diameter. The rim is about 5 feet wide and 5 feet high. It is composed of geyserite of a grayish color, and is full of deep pockets, which contain balls of geyserite about the size of walnuts, each one being covered with little rosette-like formations. The column of water thrown out by this geyser during its eruptions is very wide, and reaches the height of 50 feet. Near it we obtained some pieces of wood, which were coated with geyserite of a delicate pink tinge. The silica had thoroughly penetrated the woody fiber. We found, also, some pine-cones, coated in the same manner, forming beautiful specimens. A few yards back of the geyser were three large mud-springs, in one of which the mud was red, in another white, and in the third pink. They were all in agitation, and the jets of steam escaping caused the mud to assume the form of small conical points throughout the basins. They were situated in a bed of clay, the red color being due to iron. Below these latter there were some chalybeate springs, the bright-red iron deposit of which had spread over a considerable area and formed a glaring contrast with the white color of the siliceous material. About three-quarters of a mile to the southeast of this group is the third group, situated at the northwestern base of a spur of the mountains, and extending up a ravine a distance of one thousand yards. They occupied a space of about five hundred yards in width. One of the springs from its shape we named the Fissure Spring. We found here three sulphur springs, the only ones in the region. The amount of sulphur present, however, was not very great; their temperatures were respectively 138° F., 154° F., and 196° F. In this ravine we took the temperatures of twenty springs, averaging 158° F.; the lowest was 130° F., and the highest 196° F. About the center of the group was a small lake 600 feet long and 150 feet wide, near the eastern shore of which there was a geyser, which spouted very regularly to the height of 15 or 20 feet. A short distance southeast of the lake we found an iron-spring, which was surrounded by an abundant deposit; its temperature was 160° F. West of the lake were two geyser-cones, about 18 inches high and

12 inches across at their bases. From the top of these the water emerged. They were incrusted with a cauliflower-like formation, and near them in a fissure we obtained balls of geyserite coated in the same manner. The stream flowing from the lake is well filled with a luxuriant growth of *Confervoidea*.

About a thousand yards farther south is the fourth group. The ravine in which they are situated is about a mile and a half long and three hundred yards wide. Of the many springs and geysers which it contains, we took the temperature of forty-two, varying from 112° F. to 198° F. The average temperature was 179° F., the temperature of the air being about 60° F. Just before entering the ravine we passed by a large cone about 25 feet in height, from the top of which steam was escaping. It is probably a geyser, although during our stay it did not have an eruption. At the mouth of the ravine we found the principal geyser of the group. Its basin was circular and about 60 feet in diameter, although the spring itself, which is in the center, is only about 15 or 20 feet in diameter. The incrusted margin is full of sinuses, filled with hot water, which falls into them whenever the geyser is in operation. These pockets contain, also, smooth, rounded pebbles of geyserite, varying in size from that of a pea to a large-sized walnut. They have been rounded by the action of the water. The water in the spring of the geyser was of a blue color and constantly in agitation, though more violently so just before spouting. The column of water projected reaches the height of 100 feet, and is accompanied by immense clouds of steam. Near the upper end of the ravine was a spring, about which the deposit, instead of being white, was black. In some of the springs we found butterflies which had fallen in and been scalded to death, and on taking them out we found them coated with silica, thus commencing to undergo petrifaction.

About a thousand yards west of our camp, on the banks of the Fire-Hole River, was the fifth group, the largest of all, covering a space of nearly a square mile, and comprising a large number of springs and geysers. We recorded the temperature of ninety-five, more than one-half of which were over 180° F. They varied from 112° F. to 196° F., the average being 172° F.; the air at the time of observation was 70° F. One of the springs, from its resemblance to a shell, we named the Conch Spring. One geyser resembled a fortress with numerous port-holes, looking toward the river. Its temperature was 196° F. In the river were several small islands containing geysers. Opposite one of them, on the edge of the river, was a horn-like geyser-cone, which we named the Horn Geyser. Another we called the Cavern. There are also a number of fumaroles, or vent-holes, from which steam constantly escapes. Near the northern end of the group the river flows close to the base of a small wooded hill, along the edge of which were some mud-springs and mud-geysers, the mud varying in color, being white in some and blue in others. In some it was very thick, and in others almost as thin as water. On ascending the hill after passing through the woods, we came to a dozen or more interesting mud-springs. They were almost all situated at the bottom of large funnel-shaped craters, of about 20 feet diameter at their mouths. The mud in most of them was very thick and of a white or grayish color, and the steam in escaping did so with a dull, thud-like noise, throwing back the mud in forms resembling the leaves of a lily. Near these there were some small mud-cones, from the top of which there was steam escaping. Breaking them open, they were found to have veins of sulphur and iron running through them. About two miles southwest of the last-mentioned group

is the sixth group, situated on a small stream flowing into the Fire-Hole. They are in a large, open, prairie-like valley, which is for the most part marshy. At the head of the valley there is a beautiful cascade. We took the temperatures of thirty-four springs, varying from 106° F. to 198° F., the average being 184° F. One of the springs was strongly chalybeate. The seventh group is on the Fire-Hole River, about two and a half miles south from our camp. Here we met with the largest spring we had yet encountered. It was over 400 feet in diameter, and the sinter extended in overlapping layers for a considerable distance around it. Below this, about 600 feet from the river, was a second huge spring, which we named the Caldron. The level of the water in it was 20 feet below us, and the view of it obscured by the dense clouds of steam rising from it. The glimpses we got revealed that it was of a beautiful blue color. One side of the wall was broken down, and thence the water flowed into the river through a number of streams, forming a cascade, whose beds were lined with the sesquioxide of iron. We took the temperatures of twenty of the springs, and found the average to be 184° F. The lowest temperature was 132° F., and there were but two other springs below 173° F. One-half of the springs were above 190° F., the highest being 196° F. The air was about 70° F. to 76° F. The lower geyser-basin comprises an area of about thirty square miles, and the springs whose temperatures we took are but a small part of the whole number. They are divisible, like those of Iceland, into three classes: 1. Those which are constantly agitated or boiling. 2. Those which are agitated only at particular periods. 3. Those which are always tranquil. In the geysers the water is usually placid until within a short time of the eruption, when it begins to bubble and there is an escape of steam, the water rising gradually in the basin until suddenly it is projected into the air.

We left our camp in the lower basin about noon of the 4th of August, proceeding up the Fire-Hole River, and in the evening pitched our tents in the upper basin. This basin is not so large, occupying a space of only about three square miles, and containing a less number of springs. They are, however, much more active, and their craters are more beautiful, interesting, and larger. The majority of the springs and geysers are near the river, extending along it on both sides for about three miles. Many of them were named by the party under Langford and Doane, who visited them in 1870. Soon after getting into camp we were treated to an exhibition that was truly wonderful. Immediately opposite us, at the base of a small hill, a geyser threw a column of water to the height of over 200 feet from the earth, which shook as the water fell back into its basin. It was accompanied with a vast quantity of steam. We gave it the name of the Grand Geyser. It had but one more eruption during our stay, and that during the next night, after an interval of thirty-one hours. The deposit throughout the valley is siliceous, as in the lower basin. We recorded the temperatures of one hundred and four springs and geysers, and these were but a few of the whole number. Many of those not taken were too violently agitated for us to approach them with safety. Others were so large as to be beyond the reach of the thermometer. Two-thirds of the temperatures taken were over 170° F., the lowest being 113° F., and the highest 196° F. The temperature of the air was 67° F. The principal geysers were named as follows: The Soda Geyser, the Fan Geyser, the Riverside, the Grotto, the Pyramid, the Giant, the Punch Bowl, the Grand Geyser, the Saw Mill, the Castle, the Giantess, the Bee Hive, and Old Faithful. The Soda Geyser was two miles below our

camp, on the left bank of the river, and spouted with great regularity every ten minutes, throwing the water up 10 feet, resembling very much a soda-fountain, whence its name. The Grotto Geyser was situated about 500 yards northwest from our camp. It consists of a mass of sinter 12 feet in diameter and 5 feet high, full of large sinuous orifices, from which the water is projected during an eruption. Four hundred feet southeast of the Grotto is the Giant. The crater of this geyser is very rough and rises about 10 feet above the surrounding level. It is 8 feet in diameter at its base and 5 or 6 at the top. One side is somewhat broken down, allowing one to see the boiling water in it. It projects a column of water of about 5 feet in diameter to the height of 125 feet, the eruptions each lasting about two hours. Near the Grand Geyser, which was immediately opposite our camp, there was a small one, which we named the Saw Mill Geyser. It threw a small stream to the height of 10 or 15 feet almost uninterruptedly. Still farther up the river, and on the opposite side, is the Castle, the most beautiful of them all. It is situated in the center of a large, gently sloping mound of sinter, above which its crater rises about 20 feet. It is about 50 feet in length, and beautifully incrusted with bead-like formations. The whole mass resembles some old castle that has been subjected to a bombardment. It has an eruption every few hours. Between the Castle and the river is one of the large springs or cisterns so numerous throughout the region. It corresponds to the Laugs of Iceland, which some time in the past have been geysers. This one is about 20 feet in diameter, and is funnel-shaped. The edge is lined with a series of beautifully regular scallops. The water in this white siliceous basin is an exquisite tint, resembling the turquois blue. This intense blue, however, is not peculiar to this region. It is noticed as well in New Zealand and in Iceland. The temperature of the water was 172° F. At the head of the valley stands Old Faithful, so named for the regularity of its spouting, which takes place every fifty minutes, lasting about ten minutes, the water reaching the height of 125 to 150 feet. Its crater is conical, and 6 feet high. Near it there are four geyser-cones, which are now extinct geysers. On the opposite side of the river from Old Faithful are the Giantess and Bee Hive, neither of which were seen in operation by us.

Bunsen's theory of the geyser is the simplest and probably the most correct. It can be verified by experiment, and the facts observed by us sustain it. Briefly stated, it is this: The water deposits nothing except by evaporation, which takes place rapidly at the edges; here, then, the silica which is held in solution is deposited and builds up the beautiful tube and basin of the geyser. Bunsen succeeded in determining the temperature of the geyser-tube, from top to bottom, a few moments before eruption, and found that at no part of the tube was it at the boiling-point. How, then, does the eruption take place? It is always noticed that before an eruption the water rises in the tube. The higher we go in the tube the lower is the point at which the water boils. Suppose the column of water is elevated by the entrance of steam through ducts at the bottom of the tube. The water, which at a certain point was near the boiling-point, is elevated to a part of the tube where the boiling-point is lower than the temperature it has; there is therefore an excess of heat. This excess of heat is used in generating steam; the water is elevated higher, more steam is formed, and suddenly the water above is thrown into the air, mingled with clouds of steam, and we have the geyser in action. The water has to be very near the boiling-point before an eruption can take place.

In the Fire-Hole geysers we noticed that just before an eruption the

water rose gradually in the basin, and that there were occasional attempts at eruptions, which failed, preceding the actual eruption. A specimen of the water brought back was as clear as when bottled at the geysers, showing no deposit whatever. There was not sufficient for a quantitative analysis. It contained $835\frac{25}{85}$ milligrams of solid matter to the liter, consisting in the main of silica. Chloride of lime and sulphate of magnesia were present in small quantity, and there was also a trace of iron present. The glaring white deposit, which extends over both the upper and lower basins, is principally geyserite, a variety of opal. The forms it assumes here are similar to those found in Iceland. The specimens vary in color, form, and texture. The majority are of an opaque white, or grayish color. In the lower basin some pink specimens were obtained which are translucent; other specimens are of a greenish gray. Some of the white pieces were subtranslucent; others were pearly and enamel-like. Specimens from the geyser-cones have generally a cauliflower-like form, and break very easily; others are beaded, and still others covered with small stalagmitic processes. The texture varies from porous to compact, and some pieces are very easily reduced to powder. The majority of the deposit which extends through the basins is porous, and arranged in layers. The geyser-cones are generally very compact, and very often have an enamel-like coating. From some of the springs masses were obtained that are filamentous and stalactitic. Some pieces seem as though the surface had been enameled and then suddenly allowed to contract, leaving small, irregularly shaped plates of enamel attached to the main mass by pedicles. In the lower basin we found smooth balls, which, on being broken, were found to be composed of concentric layers of geyserite of a homogeneous structure. Others, which were beaded or otherwise fantastically fashioned on the outside, were found to be very irregular in their structure. The latter were generally of a pink color. A specimen of white geyserite, of cauliflower-like form, hardness of 5, and specific gravity 1.866, contains—

Silica	83.83
Water	11.02
Chloride of magnesium	4.00
	98.85

Analyses of geyserite from other parts of the world are as follows:

White geyserite from Iceland, (analysis by Damour.)

Silica	91.23
Water	8.97
	100.20

Geyserite from Iceland, (analysis by Forchhammer.)

Silica	84.43
Water	7.88
Alumina	3.07
Iron	1.91
Lime	0.70
Soda and Potassa	0.92
Magnesia	1.06
	99.97

Geyserite from New Zeland, (analysis by Pattison.)

[Phil. Mag., III, xxv, 495.] Specific gravity, 1.968.

Silica	77.35
Alumina	9.70
Sesquioxide of iron	3.72
Lime	1.54
Water	7.66
	99.97

Geyserite from New Zeland, (analysis by Mallet.)

[Phil. Mag., IV, v. 285.] Specific gravity, 2.031.

Silica	94.20
Alumina	1.58
Sesquioxide of iron	0.17
Lime	Indication.
Chloride of sodium	0.85
Water	3.06
	99.86

On the 6th of August we bade farewell to the Geyser Basin and started on our way toward the Yellowstone Lake to rejoin the main party. Our way led upward through dense timber, and after traveling eight miles we reached the summit of the first ridge of mountains separating us from the lake. The rock at the summit was a porphyritic obsidian, containing large crystals of feldspar thickly disseminated through it. We now began to descend, and at the foot of the mountain passed by Madison Lake, which is about five miles in diameter. It is heart-shaped. The sand on its shore is composed of finely-broken-up obsidian, intermixed with chips of chalcedony and red jasper. We were obliged to go into camp at night without having reached the lake, whose shore, however, we reached the following morning, to find ourselves about three miles below camp. Our camp was situated near a large collection of hot springs and mud-geysers. The former varied in temperature from 115° F. to 191° F., averaging 166½° F.; the latter ranged from 132° F. to 190° F., the average being 155½° F. The temperature of the air during observation was about 65° F. The water of the springs contained—

Silica,
Iron,
Alumina,
Soda,
Potassa,
Sulphuric acid.

Its reaction was neutral. In some of the springs of low temperature there was a red gelatinous organic growth. One of the most curious of the springs was situated in the midst of the lake, close to the shore. Its basin was about 3 feet above the surface of the lake, and was composed of a white deposit containing a large percentage of silica, it being of the same character as the deposit about the springs on the shore. The water in this basin, which had the shape of a truncated cone, had a temperature of 160° F. The mud springs or geysers, for they threw the mud

out to the height of 3 and 4 feet, were situated in a bed of clay. Their contents consisted of a rather thick mud of an extreme degree of fineness and of a beautiful pink color. It contained—

Iron, (abundant,)
Alumina, (abundant,)
Lime,
Silica.

Our party again divided, one portion returning to the permanent camp to bring up further supplies, another to make the survey of the lake in the boat, while the remainder of us started on the 9th of August, on our way around the lake by land. In the evening, after a ride through low, marshy ground, we camped at the head of one of its southern arms, at the base of a large reddish-colored mountain, which forms one of the prominent landmarks, being visible from all parts of the lake. The next day we crossed the mountain and pitched our tents on one of the small streams that contributes to form the Snake River. The following evening we reached Bridge Creek, or the Upper Yellowstone River, at the head of the southeast arm of Yellowstone Lake. Leaving here we proceeded down the eastern shore of the lake, which we found to be not so thickly covered with timber as the western side, nor so marshy as the southern shores. After leaving the head of the lake, we made three camps before leaving it altogether. Back of our first camp, which was on a rocky bluff, there was a high ridge of igneous origin, composed mainly of volcanic breccia, in which I obtained good specimens of wood-opal. Some of the pieces were inclosed in the center of a mass of the breccia, which seemed to have flown over it in a melted condition. Some of the specimens obtained were evidently the heart of the wood, the center of which contained chalcedony and crystals of quartz in fissures caused originally by the splitting of the wood. Our second camp was in one of the small prairies so numerous on this side of the lake. Here we were joined by the supply-train, and by the party in the boat. In the lake opposite to us was Promontory Point, a point of land running out into the water between the southeast arm and one of the southern arms of the lake. A piece of rock brought from it contained rhomb-spar and crystals of calcite, the matrix being red from the presence of iron. Near camp were two high volcanic peaks, Mounts Stevenson and Doane. The summit of the former is composed of a light-gray trachyte, containing acicular crystals of hornblende. The rock is identical with that on Mount Washburne. Between our two camps was the site of an old hot-spring basin, now extinct, to which was given the name of Brimstone Basin, from the sulphur which exists in it. The deposit, which is mostly of a white color, fills a valley that is about a mile in length, and a quarter of a mile in width. It extends up the side of the mountain in deep ravines, in some of which there is a strong sulphurous odor, although the hot springs are all extinct. The water flowing from these beds is cold and impregnated with alum, which probably results from the water passing through the sulphur and clay beds. It is acid in its reaction.

On the 19th of August we moved our camp farther down the lake to Steamy Point. Just before reaching it we passed a small group of hot springs and steam-jets, which were a few yards from the shore. There was about them a deposit of sulphur, iron, and alum. One or two of the springs contain chloride of sodium. The average temperature of these springs was $183\frac{1}{2}^\circ$ F., the highest being 198° F., and the lowest 178° F. Our camp was situated on a high bluff on the edge of the lake.

Near us there were two vents, from which the steam, in escaping, made a noise exactly like a large steamboat letting off steam. The volume of steam was very large, and the discharge constant. There were here also some small mud-springs. Every night while at this place we experienced earthquake-shocks, each lasting from five to twenty seconds. We named it Earthquake Camp. A few hundred yards back of us there is a small group of mud-springs, in which the mud was of a pure white color. About two miles northeast of the lake we discovered a small lake, which was named Turbid Lake, from the muddiness of its water. It tasted of alum, and there seemed to be numerous springs throughout it, as there was a bubbling all over its surface. On its eastern shore there was a group of hot springs, mud-springs, and vents. The largest spring was situated in the midst of a small stream flowing into the lake, and had a temperature of 186° F. On the side of a small hill, at whose base the principal mud-springs were situated, there was an abundant deposit of sulphur and alum. In some places the mud had become quite compact, and upon being broken revealed the presence of sulphur running through it in veins. Almost all these springs gave off sulphureted hydrogen gas. The temperatures varied from 176° F. to 192° F. A short distance north of this group there were some large mud-springs, one of which was white and another black. The latter had a large quantity of sulphur in its composition. On the northern shore of the lake there are four or five cold springs, containing chloride of sodium. This place is used by the deer and elk as a lick. Our horses recognized the presence of salt at once, and licked the ground with avidity. Nearly all the springs near the Yellowstone Lake seem to have passed their most energetic stage, and are now on the decline.

On the 23d of August we left Yellowstone Lake, and, taking a north-easterly direction, started on our way toward the East Fork of the Yellowstone River. The first part of our route was along Pelican Creek, one of the tributaries of the lake, which we followed to its source, crossing the divide between it and the branches of the East Fork, toward evening, when we camped at the shore of a beautiful little lake in the woods. The valley of Pelican Creek is quite wide, and the stream flows through it in a serpentine manner, its waters covered with wild ducks and geese. There were a number of springs scattered along its banks, the majority of them cold. One, however, had a temperature of 66° F. There were a few geyser-cones, although as geysers they are probably now extinct. We reached the southern branch of the East Fork the following evening, after a day of hard travel through the dense pine forests and up and down steep mountains, and camped, a few miles above the junction of the north and south branches, in a wide open valley. In the bed of the stream I obtained good specimens of agate, quartz, and chalcedony. Some were in the form of geodes, and contained opal in the center. I also obtained black flint, green jasper, and excellent pieces of silicified wood, some of which were of a jet-black color, having veins of blue chalcedony running through it. About three miles from our camp, on the north branch of the East Fork was a large mound of hot-spring formation, consisting chiefly of calcareous material resembling very much the formation at Gardiner's River. It is conical, about 20 feet high, and 25 feet in diameter at its base. It is situated on one end of a sort of platform, of the same material, which is 75 feet long, and rises 15 feet above the surrounding level. It is probably an extinct geyser, although now there is no water in it, nor is there any hot spring near. There is, however, a cold spring near it, in which the water had an acid reaction, tasting strongly of iron alum, of which there

was quite an abundant deposit about it. It is situated on the bank of a small creek, and gives off sulphureted hydrogen.

We reached the junction of the two forks of the Yellowstone on the 25th of August, having made the circuit of Yellowstone Lake, including the geysers also. Near the junction there is a large extent of ground strewn with huge granitic bowlders. Farther up the East Fork of the Yellowstone than we went there is said to be gold, although at the present time it is unsafe to mine there, on account of the Indians. I was given several specimens of galena and pyrites, said to be from that locality, from surface-diggings. We crossed the Yellowstone on the first and only bridge over its water, which was built here by one of the trappers in anticipation of a rush to the gold-diggings of Clarke's Fork. From the junction we followed our old trail, past the White Hot Springs, the Devil's Slide, and the Lower Cañon, to Botteler's Ranch, getting into the permanent camp on the 27th of August. On the opposite side of the Yellowstone from our camp, there is a high volcanic peak, one of a long chain. It bears the name of Emigrant Peak, and rises 10,629 feet above the level of the river. Its summit is composed of a very dark, compact basalt, containing a few small crystals of mica. Lower down it passes into a lighter variety. In Emigrant Gulch, which is at its base, there are granites and chloritic rocks. Specimens of pumice-stone were found near the head of the gulch. There is some little placer-mining for gold carried on in the gulch, though as yet not in a systematic manner.

We left Botteler's on the 29th of August, arriving at Fort Ellis the following day. On the way I obtained a specimen of a rhyolitic rock, having a very compact, violet-colored matrix, resembling the matrix of the felstones. It was enamel-like, and contained crystals of feldspar and mica.

On the 5th of September we left Fort Ellis, starting on our homeward trip. Fording the Gallatin and Madison Rivers, we passed the junction of the three forks of the Missouri, and camped near the Jefferson River. The valley is quite wide, and well cultivated. The only rocks observed were limestone, which continued to the Jefferson. The river cuts its way through them, forming a deep cañon, obliging us to cross the hills east of the stream. Here we encountered gneissic and granitic rocks, upon which rested beds of reddish quartzites.

On the 8th we again struck the Jefferson, and followed it until we reached its commencement in the union of the Big Hole and Beaver Head Rivers. The mountains on both sides of the Jefferson are granitic, and contain auriferous lodes. On the side opposite that on which we were there were a number, two of which are named the Highland and the Clipper. One has a depth of 300 feet, and has been worked steadily for the last three years. At the base of the mountain there are three or four quartz-mills. The formation we passed over was drift, containing quartz and granite bowlders. The Beaver Head coming in from the left, we followed it to its sources. On the 10th we camped at Beaver Head Rock. This is a huge mass of limestone, through which the river has cut its way, leaving the rock on the left bank standing with an almost perpendicular wall facing the stream. From a distance the resemblance to the head of a beaver is very striking, whence its name. Near here there is found a good quality of sandstone, which is employed in making grindstones. It is of a light-gray color, and of a good quality for that purpose. The next day we camped near Black-Tail Deer Creek, the rocks we passed having been similar to those of the day before, with the exception of red elvanites and felstones, of the same kind that

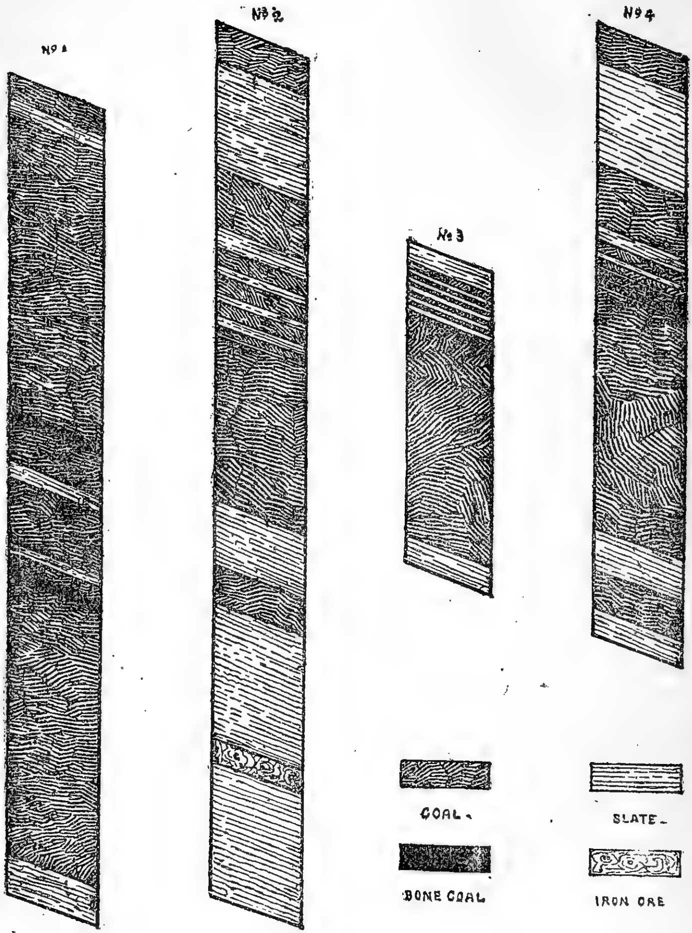
we met with on our way to Virginia City in June. They probably extend across the country. I rode up the valley for some distance, and found the mountains to be limestones, alternating with white quartzites, for six or seven miles. I also discovered a trap-dike. Near the mouth of the valley there is an old hot-spring formation, of which nothing now remains save the hard calcareous basins, overgrown with low bushes and grass. The basins are on the side of a hill, and when the springs were active must have resembled very closely the springs at Gardiner's River. There is a small stream of cold water flowing over it. Reaching the Beaver Head River again, I proceeded up the stream, through a rather picturesque cañon, at whose mouth were towering masses of a trachyte porphyry, which was vesicular, having a brown, vitreous matrix, containing small, irregular cavities coated with blue chalcedony. This rock rests upon white sandstones of loose texture, which are probably of Tertiary origin. Crossing the river, our road led us close by exposures of siliceous clay-slates, which were again succeeded by an igneous rock of a greenish-black color, and specific gravity of 2,32, the cavities being filled with masses of chalcedony varying from the size of a pinhead to two inches in diameter.

We also met with an old hot-spring formation, probably connected with the one mentioned above as occurring in Black-Tail Deer Creek Valley. The deposit is calcareous, very hard, and the springs must be long extinct. The water, which is cold, flows over it, forming a small cascade. I obtained some good specimens of calcareous tufa. We also passed some beds of bright-red sandstone conglomerates, or pudding-stone, as the pebbles were small. We obtained specimens of a brecciated rock, which seems to be a friction breccia. The matrix is of a pink color, and seems to be volcanic in its nature, while the fragments it incloses are siliceous, and of a greenish-white color. It probably occurs at the margin of the trachytic rocks found in the cañon. Our camp on the 11th of August was on Horse Plain Creek, in a valley covered in spots with quite an abundant deposit of alkali. Leaving here, the rocks first encountered were granitoid gneisses, succeeding which were alternate beds of limestones and quartzites, which continued, with the exception of a few igneous outbursts, until we reached the main divide of the Rocky Mountains, a distance of about thirty miles. On Sage Creek, in the foot-hills, there were beds of light-brown clay-slates, which were fossiliferous. We crossed the divide on the 14th of September, over reddish quartzites highly metamorphosed, probably, in part at least, by contact with an outburst of igneous rock at the same place. We proceeded down Medicine Lodge Creek, camping on that stream in the evening. We passed by a bed of old hot-spring deposit, resembling a stratified limestone. It was about 60 feet in thickness. Near camp, there was an exposure of purplish-colored volcanic rock, that I consider a trachyte, upon which rested a dark basaltic rock. Beneath these were white sandstones, very fine-grained and splitting into layers of an inch in thickness. They are probably Pliocene in their origin. Just before reaching the Snake River Valley, we ascended a broad plateau of basaltic rock, like that bordering on Snake River. In crevices in the rock, we found obsidian. We crossed Snake River the second time, finding it about 20 feet lower than when we crossed it in June. We arrived at Fort Hall on the 19th, and left on the 21st, proceeding up Lincoln Valley, between hills of Jurassic limestone. We camped in the evening at Twin Springs, where there are the remains of old hot springs. Near us there were two extinct craters, and the whole valley was overflowed with lava. The following day we reached Bear River, and turning up it

proceeded but a short distance before reaching the famous Soda Springs. There are here two settlements, and we spent a day in examining the springs. In the bed of the river there are a number from which bubbles of gas are constantly escaping through the water. The first spring which we notice is situated on the bank of the river, close to its edge, a short distance below the town. It is in the top of a cone, which is of a bright-red color, due to the deposit of oxide of iron. There is a large amount of carbonic acid gas present in the water, and its escape is so violent that the water is thrown to the height of one and two feet from the basin. It seems as though the water were boiling, so violent is its agitation. The temperature, however, is only 85½° F. The taste of the water is agreeably pungent, and slightly metallic from the presence of iron. This is the spring that Frémont named the Steamboat Spring. Near it there are two holes, from which slightly warm air and carbonic acid gas escape with a hissing noise. On both sides of the river at this point there are a number of cones of a rusty-red color, which have probably some time in the past been geysers. There is also near here a remarkable rock, that might well, from its appearance, be taken for a coral. It is of a bright-yellow color, and is composed mainly of carbonate of lime and oxide and carbonate of iron. It is, no doubt, a deposit of springs. Some distance farther up the river, in the midst of the village, there is another spring meriting attention. It is situated on the banks of a small stream flowing into Bear River. It is of the same character as the others, and has, if possible, a more agreeable taste. The basin of the spring is of a bright-red color. Between the river and the adjoining hills, which are composed of limestones, there are the remains of numerous springs. Of the majority, nothing is left but the hard calcareous material and pools of water, about which there is a deposit of alkali. Following up one of the small streams, we passed two large calcareous mounds, about 10 or 15 feet high, on top of which there were some springs, one of which was intermittent, the water escaping from it in pulsations. Near this there is a spring that has been inclosed and a pavilion erected over it. It is of the same nature as others described. The escape of carbonic acid gas is very abundant. About three miles farther up the valley we came to a most remarkable formation, consisting of the basins of old springs long extinct. They are called the petrifying springs by the settlers, from the abundance of calcareous tufa which exists in the basins. There is very little water in the springs now. Some of the basins were 6 feet in depth, and contained large masses of plants coated with the calcareous material, which retained perfectly the form of the leaf and stem. The whole area, which is about a quarter of a mile in extent, is inclosed by a fence. We left Soda Springs on the 25th of September, and proceeded up Bear River. We had gone but a short distance before we passed an old spring deposit, nothing being left but the hardened calcareous deposit. Our next camp was made at a small town named Bennington, the rocks in the hills passed by us during the day being limestones and quartzites. At Montpelier, the next town, we crossed Bear River, and, passing through the towns of Ovid, Paris, and Saint Charles, arrived at Fish Haven, on Bear River Lake. The rocks continued of the same character. We were shown specimens of ores from lodes, said to exist in the limestones. Among them were specimens of galena, malachite, and calcite. But little, however, has been done in the way of mining, as there is not, as yet, enough capital in the valley to make it profitable. Leaving Fish Haven we passed through Laketown, Randolph, and Woodruff, arriving at Evanston, Utah, on

the 28th of September. About a mile from the town there is one of the largest coal-beds in the West. It is from 22 feet to 32 feet in thickness. It crops out on the western side of a hill, composed mainly of sandstones. It dips 10° north of east. There are four slopes being worked at present, one by the Wyoming Coal and Mining Company, and three by the Rocky Mountain Coal and Iron Company. At the mine of the

Fig. 64.



Wyoming Company the main bed of coal is 22 feet thick, as shown in No. 1 of the accompanying sections in Fig. 64. It is composed as follows, from above downward:

Fire-clay roof.

	Feet.	In.
Coal		7
Slate		5
Good coal	8	3
Bone coal		3
Coal	1	2
Slate		5

	Feet	In.
Best coal	2	9
Slate		3
Coal		4
Bone coal		2
Good coal	8	0
Slate or bed-rock.		

This is the most southern of them all; and as we go farther north the bed becomes thicker. Mr. Wardell is superintendent of the Wyoming Company, which works, in addition to this mine at Evanston, mines at Carbon, Rock Springs, and Almy. Fig. 2 is a section at mine No. 1, of the Rocky Mountain Coal and Iron Company. It consists as follows, from above downward:

	Feet.
Coal	5
Clay and shale	12
Coal	7
Clay	3
Main bed of coal, with four bands of slate	26
Shale and clay	8
Coal	5
Clay and shale	15
Iron ore	3
Clay and shale	15

Nos. 2 and 3 are sections at mines Nos. 2 and 3, of the same company. They are the same, with the exception of the main body of coal, which in No. 2 is 30 feet thick, and at No. 3, 32 feet thick. In No. 3 the clay above the main body of coal is 2 feet thick instead of 3, and that below, 5 instead of 8. Mine No. 1 was commenced in June, 1869, and the main shaft has been carried in a distance of 386 feet. It is 13 feet wide, and slopes a little more than 1 foot in 4. At a distance of 150 feet from the entrance is the first level, at right angles to the main shaft. It is 15 feet in width. On the north side it has reached a distance of 330 feet from the main shaft, and on the south side 450 feet. One hundred and fifty feet below this is the second level, which on the north side has penetrated 330 feet, and on the south 400 feet. From each level chambers are worked through to the level above, parallel to the main shaft. They are 30 feet apart, and the entrance is 12 feet in width, which is rapidly widened to 18 feet. Mine No. 2 was opened in August, 1869, and has now reached a depth of 520 feet. It slopes about 1 foot in 4, and is worked on the same plan as No. 1, with this exception, that the third level, instead of commencing at the main shaft, does so at the end of shafts which branch from the main one at an angle of 45°. These shafts are, one on each side, 18 feet in width. The first level on both sides of the main shaft runs to the outcrop, a distance of 412 feet in each case. The second level, a distance of 150 feet from the first, runs to the outcrop 413 feet on the south side, and on the north has been carried 700 feet, and will go 1,000 feet when it reaches the line between it and mine No. 3. The third level penetrates 85 feet on each side. Mine No. 3 was opened in April, 1871, and has reached a depth of 190 feet. The first level only has been commenced, being 50 feet each side. It will be worked on the same plan as Nos. 1 and 2. Each mine has two engines for hoisting the coal. There are two hundred and fifty men employed, a large number being Chinamen, who live in houses erected by the company, near the mine. There is also quite a large store at the mine. The company supplies the Central Pacific Railroad, and its branches in California, and the Pacific steamship lines with coal. About 350 tons per day are mined, and the company expect to

increase this. The officers are as follows: D. Colton, of San Francisco, president; Fox Diefendorf, of Corinne, vice-president; H. K. White, of San Francisco, secretary; C. T. Deuel, resident at the mines, superintendent; and G. A. Henry, of San Francisco, general agent. The coal is a lignite, of a very black color, and having a high luster. It breaks into parallelopipeds. It contains from 71 to 73 per cent. of carbon. The value of this bed of coal can scarcely be estimated, especially as it is situated in a country where timber is so scarce, and even the small amount that does exist is so liable to be destroyed by fires in the fall of the year, as we observed on our way up Bear River Valley. The iron ore that lies beneath the coal is of a light brownish-gray color, being argillaceous. It contains 35 per cent. of oxide of iron, 30 per cent. of lime, and 20 per cent. of silica. We left Evanston on the 1st of October, and arrived at Fort Bridger the following day, where the expedition disbanded.

CATALOGUE OF THERMAL SPRINGS.

Locality.	No. of springs.	Position.	Elevation in feet.	Character.	Principal constituents.	Gases evolved.	Temperature, Fahrenheit. Highest.	Lowest.	Average.	Of air.
							°	°	°	°
Eleven miles above Ogden, Utah, four miles from the shore of the Great Salt Lake.	10	In syenites, base of Wahsatch Mountains.	4,517	Chalybeate	Iron, lime, magnesia, chloride of sodium.	Carbonic acid	136	109	129	83
Lincoln Valley, near Fort Hall, Idaho.	5	Limestones	4,720	Calcareous	Lime, alumina	do	87	69	75.8	80
Hot Spring district, Madison County, Montana.	3	Syenites	4,804	do	Lime		76	64	70	48
Do	3	Near road; rocks not known.	4,804	do	do		110	124	117	50
Gardiner's River, White Hot Springs—										
First group	5	Through limestones, and partly between them and igneous rocks.	5,545	do	Carbonate of lime, chloride of calcium, sulphate of magnesia, silica, sulphur.	Sulphureted hydrogen.	132	84	111.2	*63
Second group	5	do	6,084	do	do	Sulphureted hydrogen and carbonic acid.	162	56	121	*63
Third group	4	do	6,254	do	do	Sulphureted hydrogen.	162	116	147.75	*63
Fourth group	2	do	6,389	do	do	do	143	142	142.5	*63
Fifth group	1	do	6,522	Sulphurous	Sulphur, carbonate of lime, chloride of calcium, silica, sulphate of magnesia.	do	112	.....	.....	*63
Near Tower Falls	1	In trachyte, on bank of Yellowstone River.	6,188	Acidulous	Sulphuric acid, sulphates of iron, alumina, magnesia, and lime.	Sulphureted hydrogen, carbureted hydrogen.	127	.....	.....	70
South of Mount Washburne, east side of Yellowstone River—First group.	6	Trachytes and clay	8,000	Salses and sulphur-springs.	Sulphide of calcium, sulphates of iron, magnesia, and alumina, sulphur, silica.	Sulphureted hydrogen.	170	87	173.22	.....
Near Mount Washburne, east side of river—										
Second group	9	do	8,000	do	Iron, alumina, magnesia, lime, sulphur, silica.	do	185	132	174.2	.....
Third group	33	do	8,000	do	do	do	190	88	134.5	.....
Crater Hills, on Yellowstone River.	3	Trachytes	7,435	Sulphurous, acidulous	Sulphur, alumina, silica, iron, lime, chlorine, and sulphuric acid.	do	183.5	130	151.2	77.5
Do	2	Trachytes and clay	7,435	Salses, or mud-volcanoes.	Sulphates of iron, alumina, and magnesia, chloride of calcium, sulphur, silica.	do	188.5	163	175.5	77.5

* Average.

Catalogue of thermal springs—Continued.

Locality.	No. of springs.	Position.	Elevation in feet.	Character.	Principal constituents.	Gases evolved.	Temperature, Fahrenheit. Highest.	Lowest.	Average.	Of air.
							°	°	°	°
Mud volcanoes on Yellowstone River.	10	Trachytes	7, 438	Sulphurous, acidulous.	Iron, alumina, magnesia sulphate, sulphur, and silica.	Sulphuretted hydrogen.	187	143	171. 4	73. 5
Do	4	Trachytes and clay-beds	7, 438	Salses, or mud-volcanoes.	Sulphate of iron and alumina, sulphate of magnesia, chloride of magnesium, sulphur, silica.	do	191	163	178. 5	73. 5
Hot Spring Camp, on west shore of Yellowstone Lake.	40	On shore of lake	7, 427	Siliceous	Silica, iron, alumina		191	115	166. 5	64
Do	8	Near the lake, in a bed of clay	7, 427	Salses, or mud-volcanoes.	Alumina, iron		190	132	155. 5	64
East Fork of Madison River, near its head.	9	Igneous rocks	7, 098	Siliceous	Silica and lime		199	128	179. 2	70
Lower Geyser Basin—First group	67	do	6, 921	Geysers and siliceous springs.	Silica		198	106	158	50
Second group	16	do	6, 921	do	do		196	140	182. 5	55
Third group	20	do	6, 921	do	do		196	130	158. 2	60
Fourth group	42	do	6, 921	do	do		198	112	178	60
Fifth group	95	do	6, 849	do	do		196	112	172. 5	70
Sixth group	34	do	6, 849	do	do		198	106	184	70
Seventh group	20	do	6, 849	do	do		196	132	184	74
Upper Geyser Basin	106	do	7, 001	do	do		196	113	167. 1	67
East side of Yellowstone Lake, near Steamy Point.	6	Near the shore of the lake	7, 427	Sulphur and chalybeate	Sulphur, iron, soda, silica	Sulphuretted hydrogen.	198	178	183. 7	
Near camp at Steamy Point	3	In bed of clay	7, 427	Salses, or mud-volcanoes.	Alumina, sulphur, iron	do	180	168	175. 3	67. 5
Turbid Lake, near Yellowstone Lake, back of Steamy Point.	12	Igneous rocks and clay-beds.	7, 450	Salses and sulphurous.		do	192	176	184. 8	67. 5
Pelican Creek	1	Rocks not known	7, 500				66			
North branch of the East Fork of Yellowstone River.	1	In limestones, probably near the edge of the stream.	6, 337	Calcareous	Lime, alumina, silica, iron		*			
Soda Springs, Bear River, Utah.		Limestones	5, 529	Carbonated	Carbonates of lime, magnesia, and iron, sulphates of magnesia and lime, chlorides.	Carbonic acid	85. 5	52. 5	59. 1	69

* Cold spring.

CATALOGUE OF MINERALS.

AGATE. In pebbles on the shore of Yellowstone Lake, Wyoming Territory; in the bed of the south branch of East Fork of Yellowstone River.

AZURITE, (blue carbonate of copper.) Near Virginia City, Madison County, Montana Territory.

BIOTITE, (black mica.) In granite at the head of Wild Cat Cañon, Montana Territory.

CALCITE, (carbonate of lime.) *Brown spar* near Oxford, Idaho Territory. *Rhomb spar* near Copenhagen, Utah Territory; in the valley of the Yellowstone River; in Bear River Valley, back of Saint Charles, Utah Territory; at Promontory Point, Yellowstone Lake, Wyoming Territory. *Iceland spar* near the Crow Indian Agency, on the Yellowstone River, Montana Territory. *Crystals of calcite* on volcanic rock at Gardiner's River, near the White Hot Springs.

CHALCEDONY. Rounded pebbles, on the shores of Yellowstone Lake; in geodes with agate, opal, and quartz, on the south branch of the East Fork of Yellowstone River; in chips throughout the valley of the Yellowstone River; in geodes, with quartz and calcite, near Gardiner's River; at the foot of Mount Washburne; in cavities, in an amygdaloidal trap-rock, on Beaver Head River, Jefferson County, Montana Territory. Beautiful blue specimens in jasper, at Red Bluff lode, Madison County, Montana Territory.

CHALCOPYRITE, (copper pyrites.) Near Virginia City, Montana Territory; at Red Bluff lode, with galena, Madison County, Montana Territory.

COAL, (lignite.) Near Fort Ellis, Gallatin County, Montana Territory; at Evanston, Utah Territory.

CUPRITE, (red oxide of copper.) Near Virginia City, Madison County, Montana Territory.

FELDSPAR. *Albite*, with quartz, in Port Neuf Cañon, Idaho Territory; in granites near Botteler's, Montana Territory. *Labradorite* in granites in Wild Cat Cañon, Montana Territory. *Orthoclase* in syenites at Ogden, Utah Territory; in granites, through Idaho and Montana Territories, *Sanidine* in phonolite at Pleasant Valley; in trachytes in Grand Cañon of the Yellowstone River; in trachytes about Yellowstone Lake.

FLINT, (black variety.) On south branch of the East Fork of Yellowstone River.

GARNETS. Below Virginia City in gneissic rocks; in Alder Gulch, near Virginia City; on the Madison River, about forty miles above Virginia City; in hornblende schist in cañon of the Yellowstone River, above Botteler's; in bowlders near the cañon of the Jefferson River, near the junction of the three forks of the Missouri River.

GALENA, (sulphide of lead.) Argentiferous, near Virginia City, Montana Territory; with copper pyrites at Red Bluff lode, Hot Spring district, Madison County, Montana Territory; in the mountains along Cache Valley, Utah Territory; in limestones in the mountains in Bear River Valley, Utah Territory.

GEYSERITE, (siliceous sinter.) In the geyser-basins of the Fire-Hole River. Pink, translucent varieties in the lower basin; also small balls of the same, some smooth, others covered with a rosette-like formation; gray and white varieties, having a cauliflower-like form, abundant in both the lower and upper basins; also massive, compact, porous, and pearly varieties in both basins.

GOLD. In placer-mines, Alder Gulch, Madison County, Montana Territory; in various mines about Virginia City; in a jaspery ore at Red Bluff lode, Hot Spring district, Madison County, Montana Territory; in Emigrant Gulch, opposite Botteler's Ranch, on Yellowstone River, Montana Territory; in mountains along the Jefferson River, Jefferson County, Montana Territory.

HALITE, (common salt). In cold springs on Turbid Lake, near Yellowstone Lake; in springs near Evanston, Utah; in springs in Idaho.

HAÜYNITE. In phonolite, in Pleasant Valley, Idaho Territory.

HORNBLENDE. In syenites at Ogden, Utah Territory; in hornblende schists below Virginia City, Montana Territory; in gneissic rocks on the Madison River above Virginia City; in gneissic rocks in the cañon of the Yellowstone River above Botteler's; in acicular crystals in trachyte on the summit of Mount Washburne, near the Great Falls of the Yellowstone; in the same form in trachytic rocks on top of Mount Stevenson, near Yellowstone Lake; in a red volcanic rock with calcite at Promontory Point, Yellowstone Lake.

JASPER. Red variety associated with blue chalcedony and opal at Red Bluff lode, Montana Territory; green variety on south branch of the East Fork of Yellowstone River.

LEUCITE. In volcanic rocks near Yellowstone Lake.

MALACHITE, (green carbonate of copper.) Wild Cat Cañon, Montana Territory; near Virginia City, Montana Territory; with chalcedony near Mount Washburne.

MINIUM, (red oxide of lead.) Near Virginia City, Montana Territory.

NEPHELITE, (var. sommite.) In phonolite at Pleasant Valley, Idaho Territory.

OPAL. *Wood-opal* at the southeast arm of Yellowstone Lake; beautiful black and white specimens from Jefferson County, Montana Territory. *Semi-opal* in center of quartz geodes on the south branch of the East Fork of Yellowstone River. *Dendritic* at Red Bluff lode, Hot Spring district, Madison County, Montana Territory. *Geyserite* in the geyser-basins of Fire-Hole River.

OBSIDIAN, (volcanic glass.) In chips along the Port Neuf River, in volcanic rock; in the valley of the Yellowstone River in chips; in volcanic rocks in the Grand Cañon of the Yellowstone; massive in the mountain ridge between Yellowstone Lake and the Fire-Hole River; porphyritic near Madison Lake.

PUMICE. Emigrant Gulch opposite Botteler's; near Yellowstone Lake.

QUARTZ. In granites throughout the Rocky Mountains; in geodes, with chalcedony, near Gardiner's River; in geodes on south branch of East Fork of Yellowstone River; crystals near Virginia City, Montana Territory.

SERPENTINE, (compact resinous.) In Alder Gulch, near Virginia City, Montana Territory.

SILICIFIED WOOD. At Tower Creek at the foot of Tower Falls; near White Hot Springs at Gardiner's River; on the southeast shore of Yellowstone Lake. Handsome black specimens, with veins of blue chalcedony, on the south branch of the East Fork of Yellowstone River, in Jefferson County, Montana Territory.

SILVER. Native and as chloride, in various mines about Virginia City; near Oxford, Idaho Territory; in galena, throughout Utah, Idaho, and Montana Territories.

SPHERULITE. At the Grand Cañon of the Yellowstone River; at the southern end of Yellowstone Lake.

SULPHUR. At White Hot Springs on Gardiner's River; at Tower Creek, in a ravine near hot springs; at foot of Mount Washburne; at Crater Hills in beautiful crystals lining the crust or deposit; on the East Fork of Madison River in old, extinct, hot-spring basins; at Turbid Lake near hot springs; near Evanston, Utah Territory.

TUFA, (calcareous.) At Soda Springs, on Bear River, Utah Territory, in huge masses, retaining perfectly the shape of the plants incrusted; in Beaver Head Cañon, Jefferson County, Montana.

CATALOGUE OF ROCKS.

There were 627 specimens, including duplicates, collected during the summer, commencing at Ogden and ending at Fort Bridger.

No.	Name.	Locality.
1	Dark-red ferruginous sandstone	Ogden Cañon, Ogden, Utah Territory.
2	Reddish syenite	Do.
3	Metamorphic siliceous conglomerate	Do.
4	Protogine	Do.
5	White quartzite	Do.
6	Light-gray cherty limestone	Do.
7	Dark-bluish cherty limestone	Do.
8	Siliceous clay-slate	Do.
9	Dark-blue mountain limestone	Dry Lake Valley, Utah Territory.
10	Oolitic limestone	Cache Valley, Utah Territory.
11	Gray siliceous limestone	Do.
12	Greenstone	Bear River, Utah Territory.
13	Amygdaloidal melaphyre	Near Clifton.
14	Greenstone	Do.
15	Chlorite schist	Between Clifton and Oxford.
16	Dark-red quartzite	Above Oxford.
17	Ferruginous quartzite	Red Rock Pass.
18	White sandstone, (Pliocene)	Marsh Creek Valley, Idaho Territory.
19	White sandstone, (Pliocene, dendritic)	Do.
20	Light-brown quartzite	Port Neuf Cañon, Idaho Territory.
21	White limestone	Do.
22	Siliceous mica schist	Do.
23	Purple quartz sandstone	Do.
24	Coarse-grained ferruginous sandstone	Do.
25	Dark-blue limestone	Do.
26	Ferruginous siliceous slate	Do.
27	Red quartzite	Do.
28	Dark-gray quartz schist	Do.
29	Arkose, or feldspathic sandstone	Do.
30	White quartzite	Do.
31	Quartz porphyry	Do.
32	Greenstone	Do.
33	Chlorite schist	Do.
34	Greenish-gray quartz schist	Do.
35	White quartz schist	Do.
36	Red quartzite	Do.
37	White friable sandstone, (Tertiary)	Do.
38	Vesicular basalt	Port Neuf River, Idaho Territory.
39	Compact basalt	Do.
40	Fine-grained red sandstone	Near Fort Hall, Idaho Territory.
41	Jurassic limestone, (gray)	Do.
42	Slate-colored trachyte	Eagle Rock, Snake River, Idaho Territory.
43	Red quartzite, (highly metamorphosed)	Do.
44	Vesicular basalt	Do.
45	Compact basalt, (with white crust)	Do.
46	Lava	Cave at Hole in the Rock, Idaho Territory.
47	Slaty porphyritic phonolite	Mouth of Beaver Head Cañon, Idaho Ter.
48	Compact porphyritic phonolite	Pleasant Valley, Idaho Territory.
49	White cavernous trachyte	Near the Divide of Rocky Mountains, Idaho Territory.
50	Pink sandstone	Mount Garfield, Montana Territory.
51	White quartzite	Do.
52	Pink and white sandstone	Do.
53	White sandstone	Do.
54	Red sandstone	Do.
55	Light-brown limestone	Do.
56	Bluish-gray sandstone, (Pliocene)	Little Sage Creek Valley, Montana Territory.
57	Gray dendritic sandstone, (Pliocene)	Do.
58	Bluish-white sandstone, (Pliocene)	Do.
59	Old hot spring deposit	Do.
60	White argillaceous sandstone	Do.
61	Yellow argillaceous sandstone	Do.
62	Granite	Wild Cat Cañon, Montana Territory.

Catalogue of rocks—Continued.

No.	Name.	Locality.
63	Gneiss	Wild Cat Cañon, Montana Territory.
64	Purple felstone or petrosilex	Do.
65	Gray felstone or petrosilex	Do.
66	Yellow felstone or petrosilex	Do.
67	Red felstone or petrosilex	Do.
68	Red elvanite or quartz porphyry	Do.
69	Gray elvanite or quartz porphyry	Do.
70	Pink elvanite or quartz porphyry	Do.
71	Red felstone or petrosilex	Do.
72	Yellow felstone or petrosilex	Do.
73	Flesh-colored felstone or petrosilex	Do.
74	Gray felstone or petrosilex	Do.
75	Chlorite schist	Do.
76	Light-gray sandstone, (Pliocene)	Devil's Pathway, Montana Territory.
77	Greenish sandstone conglomerate	Do.
78	Granite	Do.
79	Blue felstone or petrosilex	Do.
80	Argillaceous sandstone	Do.
81	Yellowish-gray felstone or petrosilex	Do.
82	Gray sandstone	Do.
83	Blue felstone or petrosilex	Do.
84	Gray quartz porphyry or elvanite	Do.
85	Pink felstone or petrosilex	Do.
86	Gray elvanite or quartz porphyry	Do.
87	Jasper porphyry	Do.
88	Striped or slaty porphyry	Do.
89	Chlorite schist	Do.
90	Garnetiferous hornblende schist	Below Virginia City, Montana Territory.
91	White quartz	Do.
92	Old hot spring deposit	Do.
93	Igneous rock basalt	Above Virginia City, Montana Territory.
94	Igneous rock, (red)	Do.
95	Light-red coarse sandstone	Do.
96	Dark-brown ferruginous sandstone	Do.
97	Garnetiferous gneiss	Madison River, above Virginia City.
98	Greissen	Do.
99	Compact red sandstone	Mystic Lake, near Fort Ellis, Montana Ter.
100	Volcanic conglomerate	Do.
101	Yellow quartzite	Do.
102	Coarse brown sandstone	Spring Cañon, near Fort Ellis, Montana Ter.
103	Diorite	Above Spring Cañon, near Fort Ellis, Montana Territory.
104	Albite granite	Near Botteler's, on Yellowstone River.
105	Pinkish trachyte, with hornblende	Do.
106	Violet-colored rhyolite, with mica	Do.
107	Pummice-stone	Emigrant Gulch, Montana Territory.
108	Iron-stone	Do.
109	Chlorite schist	Emigrant Peak, Montana Territory.
110	Granite	Do.
111	Red sandstone	Do.
112	Basalt	Do.
113	Red volcanic breccia	Above Botteler's, on Yellowstone River.
114	Hornblende schist, (garnetiferous)	Cañon of Yellowstone, above Botteler's.
115	Gray gneiss	Do.
116	Green porphyritic trachyte	Devil's Slide, Cinnabar Mountain.
117	Gray porphyritic trachyte	Do.
118	Dark-green porphyritic trachyte	Do.
119	Siliceous clay-slate	Do.
120	White quartzite	Do.
121	Gray quartzite	Do.
122	Gray sandstone	Do.
123	Red limestone	Do.
124	Yellow limestone	Do.
125	Granite	Above Cinnabar Mountain.
126	Basalt coated with calcite	Gardiner's River.
127	Gray rhyolite	On mountain, near Hot Springs, Gardiner's River.
128	Light yellowish-gray trachyte	Do.
129	Dark-gray rhyolite	Do.
130	Old hot spring deposit	Hot Springs, at Gardiner's River.
131	Greenish-gray rhyolite	On mountain, near Hot Springs, Gardiner's River.
132	Yellow rhyolite	Do.
133	Blue rhyolite	Tower Creek.
134	Chalcedony, with malachite	Foot of Mount Washburne.
135	White trachyte	Grand Cañon of the Yellowstone River.
136	White and red trachyte	Do.
137	Bluish trachyte infiltrated with sulphur	Do.
138	Dark perlite-like trachyte	Do.
139	White trachyte	Do.
140	Gray rhyolite	Do.

Catalogue of rocks—Continued.

No.	Name.	Locality.
141	Spherulite	Grand Cañon of the Yellowstone River.
142	Obsidian, with spherulite	Do.
143	Pink trachyte	Do.
144	Porphyritic obsidian	Do.
145	Volcanic conglomerate	Do.
146	Old hot-spring deposit	Do.
147	......do	Crater Hills, Yellowstone River.
148	White trachyte tufa	Do.
149	Argillaceous sandstone	Mud-volcanoes, Yellowstone River.
150	Red volcanic pudding-stone	Do.
151–154	Trachytes	East Fork of Madison River.
155	Porphyritic obsidian	Near Madison Lake.
156	Trachyte	West side of Yellowstone Lake.
157	Spherulite	Southern shore of Yellowstone Lake.
158	Porphyritic obsidian	Do.
159	Trachyte	Do.
160	Trachyte, with hornblende and calcite	Promontory Point, Yellowstone Lake.
161–181	Volcanic breccia	Southeast shore of Yellowstone Lake.
182–183	Old hot-spring deposit	Brimstone Basin, east side Yellowstone Lake.
184	Gray trachyte, infiltrated with sulphur	Do.
185	White trachyte	Do.
186	Red trachyte	Do.
187	Bluish trachyte	Do.
188	Greenish trachyte	Do.
189–190	Gray trachyte, with hornblende	Top of Mount Stevenson, east side of Yellowstone Lake.
191	......do..................do	Top of Mount Doane, east side of Yellowstone Lake.
192	Obsidian	East shore of Yellowstone Lake.
193	Porphyritic obsidian	Do.
194	Red and black basaltic rock	Do.
195	Hot-spring deposit	Do.
196	Silicified wood	Do.
197	Red rhyolitic rock	Do.
198–199	Volcanic breccia	Do.
200–201	Volcanic conglomerate	Do.
202	Chalcedony	Northeast shore of Yellowstone Lake.
203–204	Hot-spring deposit	Do.
205	White and red variegated sandstone	Do.
206	White trachyte	Turbid Lake, near Yellowstone Lake.
207	Green trachyte	Do.
208	Hot-spring deposit	Do.
209	Yellowish trachyte	Do.
210	Hot-spring deposit	Do.
211	Sandstone	Pelican Creek.
212	Volcanic conglomerate	Do.
213	Basalt, (black)	South branch of East Fork of Yellowstone River.
214	Basalt, (red)	Do.
215–216	Basaltic rocks, (black)	Do.
217	Quartzite	Do.
218	Brown coarse sandstone	Near Crow Indian agency, Yellowstone River.
219	Blue clay-slate	Near Fort Ellis, Montana Territory.
220	Clay-slate	East side Gallatin River, Montana Territory.
221	Greenish-gray sandstone	Do.
222	Siliceous clay-slate	Do.
223	Dendritic sandstone	Do.
224	Limestone	Between Jefferson and Madison Rivers.
225	Granite	Do.
226	Hornblende schist	Do.
227	Granite	Do.
228	Gneiss	Do.
229	White quartz	Do.
230	Red compact sandstone	Do.
231	Yellow calcareous sandstone	Do.
232	Dark-blue limestone	Do.
233	Garnetiferous gneiss	Do.
234	Mica schist	West side of Jefferson River.
235	Quartzite	Do.
236	Clay-slate	Do.
237	White quartzite	Black-Tail, Deer Creek Valley, Montana Ter.
238	Limestone	Do.
239	Old hot-spring deposit	Do.
240	Basalt	Do.
241	Red sandstone	Do.
242	Quartzite	Do.
243	Limestone	Do.
244	......do	Beaver Head Rock, Montana Territory.
245	Coarse gray sandstone	Do.
246	Dark-purplish rhyolite	Beaver Head Cañon, Montana Territory.
247	Light-bluish rhyolite	Do.

Catalogue of rocks—Continued.

No.	Name.	Locality.
248	White sandstone, (Pliocene)	Beaver Head Cañon, Montana Territory.
249	Clay-slate, (siliceous)	Do.
250	Coarse red sandstone	Do.
251	Basalt	Do.
252	Trachyte	Do.
253	Trap-rock, with chalcedony	Do.
254	Old hot-spring deposit	Do.
255	White brecciated volcanic rock	Do.
256	Red brecciated volcanic rock	Do.
257	Hornblendic gneiss	Horse Plain Creek, Montana Territory.
258	Granite	Do.
259	Quartzite, (highly metamorphosed)	Main Divide of Rocky Mountains.
260	Purplish trachyte	Medicine Lodge Creek, Idaho Territory.
261	Gray trachyte	Do.
262	White sandstone	Do.
263	Old hot-spring deposit	Do.
264	Limestone	Do.
265	Basalt	Do.
266	Old hot-spring deposit, (yellow)	Soda Springs, Bear River, Utah Territory.
267	Old hot-spring deposit, (white)	Do.
268	Old hot-spring deposit, (red)	Do.
269	Limestone	Do.
270	Basalt	Do.
271	White quartzite	Back of Bennington, Utah Territory.
272	Red quartzite	Do.
273	Greenish quartzite	Swan Creek, Utah Territory.
274	Limestone	Near Evanston, Utah Territory.
275	Yellowish sandstone	Do.
276	Gray sandstone	Do.
277	Yellow sandstone	Between Evanston and Fort Bridger.
278	Red sandstone	Do.
279	White sandstone	Do.
280	Sandstone	Fort Bridger.

PART II.

REPORT OF PROFESSOR CYRUS THOMAS.

AGRICULTURAL RESOURCES OF THE TERRITORIES.

CHAP. I. GENERAL REVIEW: GEOGRAPHICAL FEATURES, MOUNTAINS, FORESTS, ETC.
CHAP. II. THE GREAT BASIN.
CHAP. III. NORTHERN PART OF SALT LAKE BASIN, AND SNAKE RIVER PLAINS.
CHAP. IV. MONTANA TERRITORY.
CHAP. V. LETTERS FROM PROFESSOR G. N. ALLEN AND MR. HASKILL, AND EXPERIMENTS IN CULTIVATION ON THE PLAINS ALONG THE LINE OF THE KANSAS PACIFIC RAILWAY: BY R. S. ELLIOTT.

REPORT.

WASHINGTON, D. C., *February* 1, 1872.

DEAR SIR: Herewith I present a report of my investigations of the agricultural resources of the Territories during the past season.

I accompanied the exploring party from Ogden, in Utah, to Virginia City, Montana. As it was evident the party would visit no arable areas of importance while investigating the interesting region around Yellowstone Lake, it was thought best that I should visit other parts of Montana Territory. In accordance with this opinion, I separated from the main party at Virginia City and proceeded to Helena. Here I was fortunate in finding a number of well-informed persons from all parts of the Territory, through whom I gained a large amount of information in regard to the agricultural resources of the sections I was unable to visit in person. From this point I crossed over the dividing range of the Rocky Mountains to the head-waters of the Columbia. I take pleasure in stating that my investigations have developed the fact that this interesting Territory possesses a much larger area of arable land than I had anticipated. It is true that the agricultural lands are separated into comparatively small areas; but this character has its advantage, as it secures an ample supply of water for irrigating purposes. I failed to obtain any satisfactory account of the extreme eastern part of the Territory, especially that part lying east of Fort Benton. That it consists of broad, level, treeless plains is well known, but the supply of water and means of irrigation appear to have been overlooked by those who have visited this section. As the Northern Pacific Railroad is to pass through here at some point, it is important that this should be ascertained, especially as the descent of the Missouri below Fort Benton appears to be too small to give any promise of a supply of water for irrigation from it by the ordinary methods. It is therefore important that further data should be obtained on this point.

The climate of this Territory is much more favorable for agriculture than would be anticipated from its northern and elevated position. Indian corn, of a tolerably good quality, is grown on each side of the range without any serious climatic difficulty. Even melons and fruits are matured in some of the valleys. Some have attempted to account for this by the supposition of atmospheric currents from the Pacific Ocean, &c.; but the real reason is apparent when we examine the barometer. The Bitter-Root Valley, between the Rocky and Bitter-Root Mountains, is fully 1,200 feet lower than the level of Salt Lake; and there are no broad, open plains of that extent sufficient to give play to the sweeping storm that often visits other sections.

The valleys and hill-sides are generally covered with rich and nutritious grasses, affording excellent pasturage for stock. The northwestern portion has a large area covered with extensive and valuable forests of pine, fir, and other coniferous trees. I was surprised to find the passes across the main range so easy and smooth; at one of them, Deer Lodge Pass, the water being actually taken by a canal from the Atlantic to the Pacific side.

I found the citizens everywhere deeply interested in these investiga-

tions, and always ready to assist me in every possible way, and to them I am indebted for much of the information contained in my report on that Territory. And I am glad to say that so far as I was able to test this information by personal observations, I found it generally quite correct, their great desire being not to exaggerate, but simply to get the facts in regard to their section of country before the world. I would be glad to mention the names of those who took special pains to assist me, but as I cannot mention all I hesitate to mention any, but I cannot refrain from naming Governor Potts, Colonel Wheeler, marshal of the district, Colonel Sanders, the editors of the papers of Helena and Deer Lodge, Major Forbes, Mr. Granville Stuart, and others, some of whom are mentioned in my report.

From Montana I returned to Corinne, in Utah, with Professor Allen, who had joined me at Helena. From Corinne I proceeded to California, in order to see what progress had been made here in the method of irrigating lands. I desired especially to learn what was being done in the way of lifting water. A visit to the suburbs of Sacramento, Oakland, and San Francisco soon gave me all the information on the subject that was to be obtained, as no statistics in regard to this important horticultural agency appear to have been collected. The wind-mill appears to be nearly the only power used for the purpose of lifting water, and as the quantity raised by each is small it is apparent that these cannot be profitably used for field crops, especially where they compete with the products of rain-moistened regions. But as auxiliaries to horticulture they are valuable, wherever the water is to be found in quantity at a short distance from the surface; and there are probably many points in the Territories into which your survey has extended where they could be used with profit. I append a short account of San José Valley, furnished by Professor Allen, as it contains some very interesting matter. Although California is justly celebrated for its fruits, wheat, &c., yet I was quite disappointed at the appearance of the agricultural districts visited, though this was owing in part to the very dry season; but I am convinced that the agricultural resources of this great State will never be properly developed until a more thorough system of irrigation is adopted. Although the annual rain-fall is considerable, yet it is not distributed through the growing season in such a manner as to do away with the necessity for irrigation.

I was surprised to learn no hard wood fit for wheelwright purposes, and agricultural and other machinery, was to be found on the Pacific coast. Visiting the wagon and other shops in San Francisco where hard wood is used, to ascertain where they procured it, I was surprised to learn that this is brought from the Atlantic States. I subsequently found the same fact mentioned in the report of the president of the State board of agriculture of California for 1868–'69. I had ascertained this was the fact in regard to the Territories of the Rocky Mountain region, but was not aware before that it was the case in regard to the Pacific coast. It may perhaps, without exaggeration, be said that proper timber for a wagon cannot be found in the United States west of the one hundredth meridian. As this places the States and Territories of the Pacific slope under considerable disadvantage in this respect, it seems to me that the General Government ought to take some steps to remedy the defect as far as possible. Hard wood will grow in these sections, as is evident from the experiments made, but it will probably be valueless for the purposes mentioned unless freely watered by irrigation. Would it not be well to establish in California an experimental farm and garden under the Agricultural Department? The conditions

of climate, soil, humidity, &c., in that entire region are so different from that of the Atlantic coast, that experiments in the latter section have no applicability to the former. The one is oriental, the other occidental, although reversed in position.

As I have, in a former report, given a short account of the arable areas of Utah, I have devoted a part of the present to the consideration of the physical features of the Salt Lake Basin, so far as these have any bearing upon the agricultural resources of this very interesting region. I have added a more minute account of that portion of Northern Utah over which the expedition passed the present season, and which I visited in person. I have prefixed a general outline or review of the geographical features of those portions of the Rocky Mountain regions which have been visited by the exploring party under your charge during the past three years. It would have been more systematic to have placed this at the end, but I preferred the other plan, as many persons desire to know the conclusions reached without having to read the details.

You will find, accompanying this report, a continuation of my investigations of the western *Orthoptera*. A number of new species—some twenty-eight or thirty—were obtained, and have been described, among them some of considerable interest, adding two genera hitherto unknown to the insect fauna of the United States.

I feel it to be a duty to report to you in a special manner the accommodations received from the various stage-lines running from Bozeman and Virginia City to Helena; thence to Deer Lodge; and thence to Corinne. Over all these Professor Allen and myself were passed without charge, and treated with great respect and kindness by all the officers and employés. To the Central Pacific, Union Pacific, Denver Pacific, and Kansas Pacific Railroads we are under many obligations for passes for one or both of us over these roads; and also to the officers and employés for the many acts of accommodation extended to us, by which delay was prevented. I have appended a short report of some of the valleys of Nevada, drawn up by Mr. D. H. Harkey, of Reno, procured for me by the kindness of Mr. Meecham and his partner, of Humboldt, Nevada. It is to be hoped that by another year a more complete account of this intermontane State will be obtained. I believe that Mr. Harkey is now at work upon this subject, which will probably be furnished you when completed.

I had expected a short account of the lands along the Union Pacific Railroad in the western part of Nebraska, as there is much inquiry in regard to these various sections.

It is an interesting fact that those sections of the West which have been described in your reports have received, during the past year, the greater portion of the emigration that crossed the plains. While this has, no doubt, been owing to a number of causes, yet we are justified in believing that your efforts and investigations have helped to bring about this result, and that in this fact you have an evidence of the appreciation of your labors.

I take pleasure in returning my thanks to all those persons who have so kindly assisted me in my work, and though the names of but few have been mentioned, I feel myself under equal obligations to those whose names are not mentioned.

I remain, yours, very respectfully,

CYRUS THOMAS.

Professor F. V. HAYDEN.

CHAPTER I.

GENERAL REVIEW.

GEOGRAPHICAL FEATURES.

The geographical features of a country are so intimately connected with its agricultural resources, that an inquiry into the latter necessarily involves an examination of the former. The size and character of its mountains and valleys, extent of its plains, and size and number of its rivers and lakes, are all items which must be considered if we would make our investigations complete. So far as I have noticed these in describing the separate sections, I will not repeat them further than to generalize these more minute descriptions. And it is proper for me to state here that I shall confine this review almost wholly to those Territories and regions visited in person; not that each locality alluded to has been examined personally, but that I have visited the section and learned from personal observation its leading external features.

The boundaries of the political divisions, and even the outlines of the more important natural areas, can so easily be determined from the maps, that I shall omit allusion to them, except where I may have occasion to do so for the purpose of explanation.

MOUNTAINS.

Passing over the broad plains which spread out westward from the Missouri River, the first objects to attract our attention are the mountains. We enter upon our western journey with a desire to see them, and the long monotonous ride across this broad expanse, even though sweeping along at railroad speed, intensifies that desire. And when we first catch a glimpse of some lofty peak or range, especially if it has a crown of snow upon its summit, glittering in the bright sunshine of that limpid atmosphere, all other objects for the time are forgotten. No matter whether we are enthusiastic admirers of nature's works or not, the simple fact that we are gazing upon the snowy summit of the great Rocky Mountain Range has in it a charm that, for the first time, at least, arrests the attention even of the giddy youth and suffering invalid. This first impression fixes itself so indelibly upon the mind that no matter how often we may visit this region, how various our duties may be, and how intensely we are devoted to them, yet after we have returned, often as our minds revert to that section, the mountains will stand in the foreground. Nor is this strange, for they constitute the leading and prominent geographical feature of the great West. Aside from their exceedingly important geological and mineralogical characters, which Professor Hayden and other geologists are presenting to the public, they also exhibit external features which have important bearings upon that department which has been assigned to me for investigation, and this is more especially true in this section of the country where the rain precipitation is so small and irrigation so universally necessary. From these comes the supply of water for irrigation; these are the great reservoirs upon which the hopes of the agriculturist depend. As the heat of summer approaches and the rays of the sun pour down upon his fields, he watches day by day with anxious eyes the rapidly melting patches of snow that lie upon the crest of the neighboring mountain; for, unless his ditches are fed by one of the larger perennial streams, he knows that upon the rivulets which flow from those crystal banks depend the life of his crop

and the supply of food for himself and family. He is well aware that soon after they have disappeared, the little rills will cease to flow, his ditches become dry, and his crops, unless previously matured, become parched and withered under the influence of the sun and this remarkably dry atmosphere. Hence the snows of winter, when heavy in the mountains, instead of being looked upon as misfortunes, are hailed as the sure harbingers of a plenteous harvest the following seasons. I have more than once heard the remark made by those who have long resided in that country, "It would be better for us if we had more snow;" and I am inclined to think the statement true. A hasty trip across the great mountain belt on one line will doubtless give to the casual observer the impression that there is a general sameness throughout. The broken crests and peaks of the eastern range and rugged forest-crowned Sierra will doubtless be contrasted with the broad intervening waste of ridges, valleys, and plains, but will scarcely do away with the impression of monotonous uniformity. But a closer study of these vast monuments of nature's building will show us new forms, varying features, and different characters at every step.

Instead of being arranged in continuous ridges, as was for a long time supposed, this immense belt is broken and irregular, at one point grouping its loftiest peaks and ridges in a compact mass, while at another isolated ranges have wide wastes lying between them. The water divide between the Atlantic and Pacific slopes, in some places being the crest of the loftiest ridge, running a tortuous course, winding right and left, yet with a general northwest and southeast direction, at other points it is an undefinable line on a broad and apparently level *artemisia* plain.

The mountain region reaches from the eastern slope that descends to the great plains to the Sierra Nevada; but the true Rocky Mountain belt, although vast in its proportions, is much more limited, extending, in the latitude of Colorado and Southern Wyoming, from the eastern flank to the Wahsatch Range, a distance, direct, of some three hundred and fifty miles. Here, in the western half of Colorado, eastern part of Utah, and southern border of Wyoming, is the heaviest mountain mass in the Union. Extending east and west from one hundred and fifth to one hundred and twelfth meridians, and north and south from the thirty-seventh to the forty-first parallels, it covers a quadrangular area of nearly one hundred thousand square miles. Within these bounds are collected a large number of the highest peaks and ridges of the entire Rocky Mountain belt. It is split into two parts by the valley of Green River, which traverses the entire area from north to south near the one hundred and tenth meridian, the eastern moiety containing the heaviest portion.

From the southern boundary of Wyoming to the southern boundary of Colorado, the eastern range, which lies principally between the one hundred and fifth and one hundred and seventh meridians, is exceedingly rugged, broken up into sharp peaks and tortuous ridges. On the eastern slope it is composed of an irregular series of ridges, leaning one against the other in ascending order toward the west; these at a few points separating, so as to leave large depressed areas, as the parks, Upper Arkansas Valley, &c. This form, connected with the great elevation of this entire mountain area, has a very important bearing upon the agricultural resources of the plains and valleys at the eastern base, as it affords immense reservoirs for the accumulation of winter snows, from which the streams can draw a supply of water. Hence, most of the streams which take their rise in this range are perennial, affording an

abundance of water for a broad strip of land along the eastern flank of the range. Not only are they rugged in general outline, but also in minute detail, being exceedingly rocky and jagged, except in some of the parks and larger depressions, where the local drift has rounded the lower hills. As a general thing, they are covered with heavy forests of pine and fir, except where the altitude exceeds the line of arborescent vegetation. I would call special attention here to this fact, as I wish to allude to it hereafter—the connection between the rugged, rocky surface and forest growth. In the parks and other spots where there are heavy deposits of drift, evidently brought down from the surrounding heights, as a general thing there are no forests, occasional groves of stunted cedars or piñons being the chief exceptions.

Along the east base, after passing Box Elder Creek, going south, long straight-lined foot-hills are often to be seen shooting out from the mountain side, their tops flat and almost or quite level. They are generally very smooth, without forest growth, but grassed over as evenly as a mown meadow. These singular formations constitute a very remarkable feature of this section, and give a peculiar charm to the landscape. An occasional "mesa" or squarely truncated hill can be seen here, but these are more characteristic of the country farther south.

As we approach the borders of New Mexico the mountains gradually diminish in height, the mass separating into more regularly continuous ranges; the naked crests of the higher ridges often sharply serrated. The sides, though rocky and deeply and sharply furrowed, are hardly so rugged as farther north. As might be inferred from these characteristics, the accumulations of snow are less extensive, the water more rapidly carried off, and the streams less permanent than in the vicinity of the mountains farther north in Colorado.

The Raton Mountains, which run east from the main range, near the dividing line between the two Territories, form a rather singular exception to the general direction of the eastern ranges. In their external features they are much like the mountains with which they connect in some respects, while in others they remind us more of some of the mountains in Southeastern Kentucky. They are tolerably well timbered, much of it being of a very fine quality. They give rise to the Purgatory and Cimarron Rivers.

Passing over this range to the south side, one of the most striking features of the landscape is the large number of isolated "mesas." These singular elevations, in the form of truncated cones or pyramids, with flat and horizontal tops and sharp outlines, rise up from the level plains, or from the surface of a broad valley, and almost invariably without any lateral connection with any other elevated ground. In extent they are widely different, some presenting a table surface of but a few acres, while others have nearly as many square miles. It is evident that these are beyond the reach of irrigation, from any natural reservoirs or streams, their only value being as grazing fields.

This eastern mountain group appears to have two culminating points or radiating centers; the northern, and principal one, lies immediately around the North and Middle Parks, and forms the rim of these elevated basins; the other lies immediately southwest of South Park. In the first of these, Blue River, White River, Bear River,* North Platte, and a number of the tributaries of South Platte, take their rise. In the other, Grand River, the Rio Grande, Arkansas, and main branch of the South Platte have their sources. The parks act as huge cisterns for the

* This is not the Bear River of Salt Lake Basin, but connects with Green River.

reception of the numerous little mountain rivulets that flow down from the surrounding rim, collecting them together and discharging them at one outlet. Thus the North Park collects the various streams which form the North Platte; the Middle Park, those that form Blue River; South Park, those to form the South Platte; the San Luis Park, those to form the Rio Grande; and the Upper Arkansas Valley, which is a true park, those to form the Arkansas River. Here, then, we see that five of the great rivers of this vast central region have their sources close together in this mountain area. Upon the peaks, ranges, parks, and forests embraced between the one hundred and fifth and one hundred and seventh meridians and thirty-eighth and forty-first parallels, an area not exceeding eighteen thousand square miles, depend, in a great measure, the agricultural resources of an area of more than one hundred thousand square miles.

Before passing over to the west side of the section under consideration, I would call attention to the Black Hills, (or Laramie Range,) of Wyoming, which seems to be the real northern extension of the Colorado Range, but the continuity is somewhat broken at the gorge of the Cache-a-la-Poudre, and it takes the form of a huge appendage, like the claw of a crab. Circling round the eastern and northern portions of the great Laramie Park, it acts as a bracing wall to this vast elevated plain, whose surface is fully 1,500 feet above the plains at the eastern base. Its external, or eastern slope, presenting a much longer descent than its inner or western face, differs considerably in character from the latter; while the latter, at least as far north as the gorge of the Laramie River, presents comparatively smooth and rounded surfaces, the former is rugged, and, especially along the northern part, deeply gashed by rough and rocky cañons. The intervening ridges are quite rugged up in the mountain near their origin, but as they descend to the plain they gradually lose their rough character, and grow smoother and rounder, and, seen transversely, present a succession of rounded foot-hills, which appear like the waves of the sea. The eastern flank and summit are tolerably well wooded, and the northern portion appears to have a timber growth pretty generally distributed over it, but interrupted by numerous open, field-like spaces. Numerous small streams that form tributaries to the North Platte have their origin on the eastern slope, while on the west but one or two have their sources in this range.

Between the eastern and western portions of this mountain group intervenes a broad but irregular depression, forming the Green River basin. The broad, elevated plain, formerly called the Colorado Desert, which stretches north and south from the Wind River Range to the Uintah Mountains, and east and west from the Wahsatch Range to the imperceptible divide, separating it from Laramie Plains, forms the upper portion. Having a gentle southern slope, and inclination to a central channel, it collects the waters, which once evidently formed an immense lake, against the mountain barrier at the south margin, of which an account will be found in Professor Hayden's report for 1870. Having, in the geological past, burst through this barrier, a tortuous channel has been formed for the waters, by which they connect with the Colorado River and its vast water system farther south, receiving large contributions from right and left in its passage.

Shooting out from the Wahsatch Range on the west, the Uintah Mountains stretch directly eastward, forming the southern wall to the upper portion of this basin, forcing Green River, in making its exit from the northern plains, to bend eastward in order to flank them. This range, which has a direction the reverse of the general course of the mountains

of this region, possesses features peculiar to itself. Although rising at points, as will be seen from Professor Hayden's report, to a height of 12,000 and even 13,500 feet above the level of the sea, shooting up sharp and lofty peaks above the limit of arborescent vegetation, yet it possesses, to a greater or less degree, that peculiar evidence of the remarkable effects of erosion seen in the lower ridges in this section. But the description of this interesting region by Professor Hayden is so full that it is unnecessary for me to add more than that here is found a heavy forest growth of excellent pine timber, which on account of its proximity to the Union Pacific Railroad will probably, at no very distant day, prove a source of wealth to this region.

Passing a little farther westward, we encountered the great Wahsatch Range, which, stretching north and south for four hundred miles, forms the vast terrace above the Great Salt Lake Basin. To understand the relation that this range bears to the eastern range running through Colorado and Wyoming, we must bear in mind the fact that from Salt Lake to Cheyenne there is one great mountain which has been lifted in the air an average height of 7,000 feet above the level of the sea, and between 2,000 and 3,000 feet above the mass of *débris* piled against its flanks. Its broad summit formed of the plains, hills, ridges, and peaks which intervene, these ranges are its flanking walls, forming the eastern and western escarpments. The Wahsatch Range, though rugged and rocky, does not, at least on its western slope, possess the jagged character to such a high degree as the Colorado Mountains, but, on the contrary, is sharply indented and furrowed, much like the Sierra Blanco Mountains which surround San Luis Park on the northeast. The western slope, especially from Ogden to the south end of Utah Lake, instead of sloping down regularly to the surface of the basin, seems to plunge down through the *débris* which presses against it as the cliff plunges down into the waters of the ocean which lave its side. There is here but one culminating point, which acts as the radiating center for the water systems of the region. This is at the place where the Uintah Mountains connect with the Wahsatch Range, almost immediately at the southwest angle of Wyoming Territory, but situated in Utah. Here White, Uintah, Bear, Weber, and Provo Rivers have their origin, the first two connecting with Green River and the others entering the Salt Lake Basin at different points.

Moving northward across the broad, open space occupied by the Green River Plains and Laramie Plains, the one lying on the Atlantic and the other on the Pacific slope, connected by an imperceptible divide, we encounter another striking feature, varying the apparent monotony of this mountain region. I say "apparent monotony," for, in reality, the scenery is constantly changing at every step to the ardent student of nature. Stretching east and west from the north end of the Black Hills of Wyoming to the south end of the Wind River Range is a series of remarkable granite hills skirting the valley of the Sweetwater. These have much the appearance of the sharp peaks and crests of a submerged range, which, shooting up through the sea of sand, mark its course. So striking is this appearance that even the most casual observers almost involuntarily make the comparison.

From this point northward the range (by this I intend the entire belt) contracts and changes its direction. From the thirty-seventh to the forty-third parallels its course is almost directly north, and extending in width from the one hundred and fifth to the one hundred and twelfth meridians, an air-line distance of about three hundred and fifty miles. Here it bends northwest, making an angle with its former course of some twenty or

twenty-five degrees, and, the eastern flank diverging a little more rapidly than the western flank, the two approach, narrowing the width of the belt toward the north. While this is true as a general statement, it must not be supposed that in attempting to follow it out in detail we shall find any great uniformity, for we shall proceed but a comparatively short distance up the western flank until we encounter the rugged Salmon River Mountains, pressing against the belt at its narrowest point like a huge goiter upon the neck. But the most interesting group within this part of the belt is to be found in the northwestern part of Wyoming, which has been the objective point of the present year's expedition, and of which a very full and deeply interesting account will be found in Professor Hayden's report of the present year, and to which this report forms an appendage. I shall, therefore, refer to it only so far as its features bear upon the agricultural resources of the surrounding regions; and, moreover, although passing closely around the western and northwestern flanks, and crossing the axial range at its western exit, I did not in person visit the magnificent scenery immediately surrounding Yellowstone Lake, which lies near the central point of the group.

The northern limb of the Wahsatch Range, separating the waters of Green River from those of Bear and Snake Rivers, penetrates northward near the western border of Wyoming Territory. Wind River Range, stretching northwest from South Pass, rising in altitude as it advances until it culminates in Frémont's Peak, forms the divide here between the waters of the Atlantic and Pacific, represented by Green and Wind Rivers. The west branch of the Big Horn Mountains, reaching across the Wind River Valley, leaving a deep gorge for the passage of this stream, directs its course toward the same central point; and the main Rocky Mountain Range from the north here bends its course eastward to connect with the others at the great point of union. In other words, here is the culminating point of the great northwestern mountain belt, from which radiate not only its chief mountain ranges, but also, as a natural consequence, the principal streams of the section. The Big Horn, Yellowstone, Madison, Green, and Snake Rivers all have their origin here, the first three finding an outlet for their waters through the Mississippi to the Gulf of Mexico, the next through the Colorado of the West to the Gulf of California, and the last through the Columbia to the Pacific Ocean, three thousand miles from the exit of the first. Here, amid a collection of the most wonderful scenery on the continent, is found the chief radiating point of the water-systems of the Northwest, being equaled in this respect only by the mountain group of Colorado Territory. A result naturally to be expected from this formation follows, viz, an abundant supply of never-failing streams. It is also interesting, on account of the influence it has upon the course of the minor streams, to notice the obstinate tendency of the minor ranges to maintain the north and south direction so common in Territories south and in the Salt Lake Basin. The Teton Range, between Henry's Fork and the main branch of Snake River, the northern arm of the Wahsatch, the main range of the Big Horn Mountains, between the waters of Big Horn and Powder Rivers, and even the ridge separating the two branches of the latter stream, though varying much in character, all have this course almost direct. If we pass north of the group into the southern part of Montana, we find this holds good with respect to the ridges which separate the tributaries of the Upper Missouri. The divides between Stinking Water and the Madison, between Madison and Gallatin, and between Gallatin and the Yellowstone, all preserve

the same north and south direction, notwithstanding the remarkable and enormous flexure of the great dividing range of the Rocky Mountains. Nor does this stop here; for if we cross the divide again and enter the basin of Clark's Fork of the Columbia, we find the same thing there on a reduced scale, the ridges which separate the southern tributaries of the Hell Gate, with no considerable exception, following the same rule.

In consequence of this general direction of the minor ranges and ridges, the smaller streams have generally a north or south course, while the larger streams, to which they form tributaries, with one chief exception, Green River, run eastward or westward. For example: Powder, Tongue, and Big Horn Rivers; Yellowstone and Missouri, above their bends; Clark's Fork of Yellowstone, Gallatin, Madison, Stinking Water, and Beaverhead Rivers, on the Atlantic slope; and Deer Lodge River, Flint and Stony Creeks, and Bitter-Root River, on the Pacific slope, all run north; while Green River, the upper part of Snake River, and Henry's Fork run almost directly south. I might add to this list, but these are sufficient to show that there is some great law which governs their direction, or that there is a remarkable uniformity.

The direction and character of the mountains in the northwest part of Montana are hereafter alluded to, and it is therefore unnecessary to state them here.

I have not visited the Salmon River Mountains, and therefore have no very correct idea as to their character, but understand that they are quite rugged and irregular. They give rise to but one important stream, the Salmon River. And I may add here that an inspection of the best maps of this but little-known section shows that here the same tendency of the minor ranges to maintain the north and south direction prevails, in consequence of which the upper portion of the river, and a number of its tributaries, run north; and Snake River, for two hundred miles of its passage through this latitude, has the same direction.

This is but an imperfect sketch of the mountain character of this great elevated region, which, in many respects, presents more of the oriental than of the occidental features. If we could stand at the extreme southern end, and, looking north, take in at one view the entire reach from the Missouri River to the Pacific Ocean, it would, between the thirty-seventh and forty-fourth parallels of latitude, present the following outlines: From the Missouri west, for four hundred miles,* we should see an inclined plane gradually ascending from 900 feet at its eastern limit, to 5,000, above the sea near its western extremity; slightly curving upward, making the ascent a little more rapid in this part. Here we would see a rugged wall shooting from 3,000 to 5,000 feet higher, while west of it, for three hundred and fifty miles farther, would be seen an irregular surface, slightly depressed in the middle, but having a general level of 2,000 feet above the inclined plain east. At the western border we should observe another rugged wall rising one or two thousand feet, and descending, on its west flank, 2,000 feet below the surface east of it. West from here we would observe the line preserving this level for some distance, then curving upward somewhat rapidly, until it reached an elevation of 6,500 feet above the sea, would gradually descend a little below the line, immediately west of the last wall. Here we should see another wall rising up to a height of 8,000 feet above the sea, from which the line, at first curving rapidly downward, would descend to the level of the Pacific Ocean.

* I limit these distances to direct measurement.

RIVER SYSTEMS.

As I have repeatedly stated, and as is well known, the chief divide of the waters is the main ridge of the Rocky Mountains, running generally a northwest and southeast course, separating the waters of the Atlantic from those of the Pacific, consequently giving two general slopes, one to the east, the other to the west, modified by lateral ranges, mountains, &c. I have already alluded to the north and south course of the minor ranges as modifying the influence of the general slope, crossing, at right angles, the natural direction of the water coming down from the chief divide, turning the minor streams north and south. But there is also another very important modifying feature, which has much to do with giving form to the water-basins and the general course of their water drainage. This is a great transverse divide, which, though not so prominent and perceptible as the great longitudinal one, is equally potent, so far as acting as a dividing water-shed is concerned.

Starting near the northwest corner of Nebraska, it runs westward to the northwest corner of Nevada, making a sharp bend northward along the west boundary of Wyoming, around the upper arm of the Green River Basin.

By examining a good map, the influence of this almost imperceptible divide upon the water systems of this region will be seen at once from the direction the principal streams flow to reach their respective reservoirs. By crossing the Rocky Mountains somewhat at right angles, it forms four great basins, the one sloping to the northeast, the waters of which are drained by the Upper Missouri, the one to the northwest being drained by the Columbia, the one to the southeast being drained by the Platte, the one to the southwest being double, the Great Salt Lake Basin and the Green River Valley.

The waters of the northeast and southeast basins reach the Mississippi through the same channel, the Missouri. The plains at the base of the mountains in Montana having a much less elevation than those lying along the east base of the range in Wyoming and Colorado, and the distance the waters of the former have to traverse to reach the junction of the two being much greater than that of the latter, it follows that the descent of the former is much less rapid than that of the latter. Hence, we find that while the Plattes have a descent on the plains of from five or six to eight feet to the mile, that of the Missouri east of Fort Benton is only about two feet to the mile. Therefore, while it will be possible, by extensive canals, to utilize the waters of the former streams in irrigating the plains which border them, the same thing would seem to be impossible in regard to the waters of the Missouri, or its chief tributary, the Yellowstone. Possibly something may hereafter be done in the way of raising water by machinery, but this can be made remunerative only at certain points, and to a very limited extent. Husbanding the water during freshets, when a higher level is reached, may also be practicable, to a limited extent; but I know too little in regard to the rises in this stream to express any opinion on this point.

Lewis's Fork of the Columbia, (Snake River,) which, in the southern part of Idaho, traverses an extensive plain, has a descent of certainly not less than six or eight feet to the mile; and as the bordering lands are low and comparatively level, there is no apparent reason why its waters may not be utilized to their full extent in irrigating this plain.

How far the waters of these streams may be rendered useful as a means of transportation, I cannot say. That the Plattes and Snake River, as they now are, are not navigable, is quite certain; but I see no

reason why a system of canals may not be constructed which would not only afford water for irrigation, but also a means of transportation, unless it be that it would not be remunerative. At present, such projects are impracticable, the population of that section not requiring them, and the slow movements of this mode of transportion are not adapted to present requirements. But the day may, and probably will, come when a canal from the upper waters of the North or South Platte, or of the Arkansas, to the Missouri or Mississippi, will justify the transportation of minerals and products of the Rocky Mountain regions, which would otherwise be valueless. It is possible a difficulty would be experienced on account of the porosity of the soil, but so far as tried for irrigating ditches no difficulty, so far as I am aware, has been experienced in this respect; but these, it is true, have a much greater descent than could be given to a canal intended for transportation. But in summing up the resources of this portion of the country, these should not be overlooked because they would not at present be remunerative.

FORESTS, TIMBER, ETC.

We may state, as a general fact to which there are but few exceptions, that west of the one hundredth meridian there is no other useful timber than pine and fir until after we have crossed the Sierra Nevada Range, and if for the California side we add the celebrated redwood, we embrace nearly all the important timber in the western part of the United States. While the Territories and Pacific States have many advantages of which they may with propriety boast, it is useless and unwise to shut our eyes to the fact that the general scarcity of timber is a serious drawback. West of the one hundredth meridian the timbered land cannot be fairly estimated at more than one-twentieth of the whole area. This is the estimate given for California by C. F. Reed, esq., president of the State board of agriculture, and is as high an estimate as can fairly be made for the entire western section of the Union. And if we exclude from the calculation Oregon, Washington Territory, the northern parts of Idaho and Montana, even this would be too high. As a matter of course, if we look at the mountain region of California and Northwestern Wyoming, the Uintah and Colorado Mountain groups, Northwestern Montana, Oregon, and Washington Territory, this estimate will appear to do injustice to the country. But when we take into consideration the broad, treeless plains stretching eastward from the base of the main range, the naked hills, valleys, mesas, and plains of New Mexico, Arizona, and Western Utah, the barren plain of Green River, treeless expanse of the Laramie Plains, the smooth and rounded hills and slopes of Southern Idaho and Southern Montana, and compare their extent with the narrow, timbered strips that skirt their streams and occasionally flank the elevated ridges, we will be apt to think the estimate rather too high. But for fear I may be accused of doing injustice to this country in these remarks and others I desire to make on this subject, I will quote the very appropriate and timely remarks of C. F. Reed, esq., president of the California State board of agriculture, published in the Transactions of the California State Agricultural Society for 1868–'69:

"We have frequently called the attention of our agriculturists to this subject, (tree and forest culture,) and have at different times urged action in its behalf by the legislature. No more important subject can be named for legislative encouragement or for energetic action on the part of the people. We are all interested in whatever affects the com-

forts of individuals and the prosperity of the country. The subject of a plentiful supply of lumber and wood for the various purposes of life is one that we cannot much longer neglect. Whoever takes the trouble to look this subject fully in the face, and reflects upon the future of California, must feel, as we do, that something should be done, and that immediately, looking to the substitution of new forests in the place of the old ones in our State, now so rapidly being consumed and destroyed. A full discussion of this subject cannot be entered into in the short space allowed in a mere report, where so many subjects of interest claim attention. But we propose to notice some facts and make some suggestions, which may lead to further investigation and, we hope, to energetic action.

"We have become so accustomed to speak of the forests of our State, of our 'big trees,' as the grandest and most majestic in the world; we hear so much of the vast quantities of timber and lumber being shipped from those forests, to supply the nations of the earth with masts and other heavy timbers for ship-building and other purposes, that we have thoughtlessly come to regard our supply of these materials and of materials for fuel as practically inexhaustible. The facts are quite different. Although the forests we have are properly a subject of State pride, they are as properly a subject of State protection. California is far from being a well-timbered country. Nearly all the timber of any value for ship and general building purposes, or for lumber for general use, is embraced within small portions of the Coast Range or the Sierra Nevada districts. Redwood, the most valuable timber in the State, and probably in the world—taking all its qualities into consideration—is principally confined to the counties of Mendocino, Sonoma, and Santa Cruz. Monterey, Santa Clara, and San Mateo contain but small tracts each covered with this valuable timber. Humboldt, Trinity, Klamath, and Del Norte embrace nearly all the balance of the timber of value in the Coast Range. It mostly consists of an inferior or hybrid redwood, spruce, and pine. The lumber district of the Sierra Nevada is principally embraced in the counties of El Dorado, Placer, Nevada, Sierra, Plumas, and Siskiyou. Calaveras, Tuolumne, and Mariposa contain only scattering clusters of valuable timber, though some of the largest and finest trees in the world are found within their borders. The timber of this district is mostly different varieties of pine, spruce, and cedar. The other mountain-counties of the State afford very little timber of any account for building purposes or for lumber. The agricultural counties, as a general thing, have only narrow strips of timber along the water-courses, consisting mostly of scrub-oak, cotton-wood, sycamore and willow, of but little general value except for fire-wood. The surface of our best timbered counties is not, in general, half covered with valuable timber. It is therefore safe to estimate that not over one-twentieth of the surface of the State is covered with forests containing trees valuable for timber or lumber.

"It is now but about twenty years since the consumption of timber and lumber commenced in California, and yet we have the opinion of good judges, the best lumber-dealers in the State, that at least one-third of all of our accessible timber of value is already consumed and destroyed. If we were to continue the consumption and destruction at the same rate in the future as in the past, it would require only forty years therefore to exhaust our entire present supply. This, in itself, seems like a startling proposition, but let us look a little further, and we shall find truths and considerations more startling still. In the twenty years to come we will probably more than double our population, but let us as-

sume that we will only double it. As a general rule, in a new country the consumption of timber increases in about double the ratio of population. Thus while the increase of population of the United States from 1850 to 1860 was 35.59 per cent., the increase of the consumption of lumber was 63.09 per cent. Upon this basis and rule, the whole available lumber of our State will be consumed and destroyed in twenty years instead of forty. We must also take into consideration in this connection the fact that we are now just entering upon an era of active public improvements, all requiring the use of heavy timber and lumber. The building of railroads, bridges, warehouses, wharves, factories, bulkheads, and the timbering of mines, will probably consume ten times as much lumber within the next twenty years as has been consumed for these purposes in the past twenty years. The building and equipping of railroads may be considered a new and special element in the increased consumption of lumber, as this business in our State has really but just commenced. One of the worst features of the settlement of new countries by Americans is the useless and criminal destruction of timber. In our State this reckless and improvident habit has been indulged in to an unprecedented extent. Thousands upon thousands of the noblest and most valuable of our forest-trees in the Sierra Nevada districts have been destroyed, without scarcely an object or purpose, certainly with no adequate benefit to the destroyer or any one else. This practice cannot be condemned in too severe terms; it cannot be punished with too severe penalties.

"South of California, on the Pacific coast, there is but very little timber or wood of any description. The Pacific South American States are, in fact, dependent on us, and the coast States north of us, for nearly all their lumber. They have been drawing heavily from these sources to rebuild their wharves and public works destroyed by the earthquakes of 1868. On the north, Oregon, British possessions, and Alaska are generally well timbered. We have, for the past five years, been obtaining large quantities of lumber from these countries, and now that the Central Pacific Railroad has advanced the freight on lumber from our own mountains fifty per cent. over former prices, our trade in this direction will still increase.

"While these countries contain a large supply of very excellent timber, this supply is by no means exhaustless. At this time almost the whole world is drawing its supply of heavy timber from the Northern Pacific coast. England, France, Australia, China, Japan, South America, Mexico, and Sandwich Islands are all, more or less, engaged in securing their wants for ship-building and other heavy works from these valuable forests. With the heavy drafts on these countries, added to their home consumption, it is not probable that the supply will hold out much longer than that of our own State.

"In the above statements and estimates, we have only taken into account such timber as is fitted for building and for lumber for general purposes. As to hard wood, fit for wheelwright purposes and agricultural and other machinery, we may say there is none of it on this coast. We have always either imported the machinery or the material to make it of from the Atlantic States. For ornamental work we have a limited supply, the California laurel being very superior.

"After what has been said above, we hardly need to comment on the scarcity of timber in the State for the general purposes of fuel. Taking all the agricultural counties in the State together, including the cities and towns within them, and considering the probable increase of population, it is very doubtful whether, under present management, they

will be able to supply their own demands for fuel for ten years to come. While it will pay, in case of necessity, to freight lumber and heavy timber great distances by land, and to ship it by water half-way round the globe, it becomes very burdensome and oppressive to all classes of the community to be compelled to convey wood for domestic and manufacturing purposes comparatively but small distances. To illustrate this proposition we need only to mention the fact that while there is within an area of twenty miles from either of the cities, Marysville, Stockton, or Sacramento, a plenty of wood for a year or two's supply, and it costs but $2 a cord to have it cut, yet the present price of wood in each of these cities is about $10 a cord. Even at this high price the owner of wood-land thirty miles from Sacramento, on the line of the Central Pacific Railroad, can make that wood net him only one dollar and a half a cord delivered in the city. These facts show how extremely expensive and oppressive it would be to undertake to supply the cities of the State with wood from the distant mountains. And yet what other resource will be left a very few years hence? California should at no distant day become one of the greatest manufacturing States of the Union; but where will we obtain the fuel with which to generate the steam that propels the machinery? Again, a new element of calculation on this subject has just been introduced among us and will grow rapidly in the future. We refer to the consumption of fuel by the railroads. There are now in the State, completed and in operation, about seven hundred miles of road. In a year from now it is safe to say there will be over a thousand; call it one thousand even. It requires one cord and three-fourths of wood, with an ordinary train, to drive an engine twenty-five miles. Now, assuming that an average of ten trains a day will then be running over this one thousand miles of road for three hundred and twenty days in the year, and we have a distance of three million two hundred thousand miles traveled in a year. As each twenty-five miles of distance traveled will consume one cord and three-fourths of wood, the consumption on one thousand miles of road will be 224,000 cords per year. In twenty years we will probably have four thousand miles of road completed, averaging twenty instead of ten trains per day, and consuming 1,792,000 cords of wood per annum. This, added to the increased consumption for all the other purposes of life, will make rapid inroads into the few sparsely wooded portions of our State, if there should indeed be any trees left standing at that time.

"The first effect of a scarcity of lumber and wood will be to enhance the cost. We have already noticed the high price of wood delivered in our cities. Lumber has not advanced very much in value for the last ten years except indirectly. The cost of cutting, manufacturing, and getting to market has been decreasing, while the cost to the consumer has remained the same. It is the opinion of dealers that it will soon increase in value very materially. It cannot be otherwise, as we have shown that the demand will increase rapidly and the supply decrease. Even now the cost and scarcity of these articles is having an oppressive effect on every industry in the State. The expense of agricultural implements and tools here, over their cost in the Eastern States, is already operating as a serious drawback upon the thrift and profit of our farmers, brought in close competition, as they now are, with their neighbors of the western Atlantic States. The cost of lumber for building and fencing, in most of our agricultural districts, obtained, as it is, at a distance of hundreds of miles away, is even now so great that our farmers are among the poorest-housed people of any agricultural community in the Union where the country has been settled an equal length of time. Their crops and stock

are but poorly sheltered, if at all, and their farms are worse than poorly fenced. To the expense of lumber more than to any other cause must be attributed the general dilapidated appearance of our agricultural districts. Efforts to improvement in these respects lead to a forced system of farming; too frequent cropping and little or no nursing of the land; to that sameness of production which we have had cause so severely to condemn. The cost of lumber and of wood is already discouraging every mechanical, every manufacturing, and every commercial industry of the State; for the use of these articles is in some way an important element in them all. The advancement of all our towns and cities in building and improvement is being now retarded very much, directly and indirectly, by the cost of these necessary articles of life. The cost of houses enhances the price of rent. The price of rent and cost of wood add materially to the general expenses of living, and these in turn enhance the price of labor of every kind, and consequently decrease the production and retard the general prosperity and improvement of the cities and country. If this be the case now when we are so young and our population so thin, when the demand for these articles is increased twenty-fold and the supply decreased in the same ratio, who can depict the condition of our State?

"We have estimated that not over one-twentieth part of the surface of our State is now covered with heavy timber, and we believe we are within the bounds of truth when we state that not over one-eighth of the entire surface is covered with trees of any description whatever. It is the opinion of the best judges, founded on historical facts and a long series of observations and experiments, that at least one-third of the surface of any country should be forests; that this relation between forest and cultivated land will secure the most advantageous conditions of climate, and the greatest amount of productions for the sustenance of human and animal life. Fire has undoubtedly been the original and active cause of so great a proportion of prairie or untimbered land within our borders. Being once destroyed, the consequent climatic condition of the country has prevented a reproduction of the original forests. Nature now, unassisted by man, can never effect that reproduction, without some great physical revolution that will change the whole features of the country. That the nakedness of the earth's surface is the cause of the extreme wet and dry seasons in our State, and particularly of the destructive floods to which the valleys are subject, cannot for a moment be doubted by any one at all acquainted with the laws of nature, and the agency of those laws in the production and modification of climate through the forests of a country. For want of space we cannot enter into a full discussion of this important branch of this subject, but will state a historical fact in the language of one of the best authors who has ever written on this subject. Hon. G. P. Marsh, speaking of the effect of the destruction of forests upon the different countries of the earth, says: 'There are parts of Asia Minor, of Northern Africa, of Greece, and even of Alpine Europe, where the operation of causes, set in action by man, has brought the face of the earth to a desolation almost as complete as that of the moon. The destructive changes occasioned by the agency of man upon the flanks of the Alps, the Appenines, the Pyrenees, and other mountain regions in Central and Southern Europe, and the progress of physical deterioration, have become so rapid that, in some localities, a single generation has witnessed the beginning and the end of the melancholy revolution.' Words could not more truthfully describe the effects produced by similar causes in some portions of our own State. Mr. Marsh continues: 'It is certain that a desolation like

that which has overwhelmed many once beautiful and fertile regions of Europe awaits an important part of the territory of the United States unless prompt measures are taken to check the action of the destructive causes already in operation.' This last remark applies with greater force to a large share of our own State than many of us are aware of.

"In many countries where rains are of frequent occurrence during the summer season, keeping the surface of the soil moist, vegetation, however delicate and tender, once started in the spring of the year, continues to grow until checked by the succeeding autumn or winter. By this time the roots have obtained such a hold on the ground as to secure continued life, unless destroyed by artificial causes. Not so in our State. The dry season here follows so rapidly after the wet and germinating period, that, without irrigation or cultivation, tender and delicate plants, like young trees of all kinds, grown from seed lying on the surface, as they fall from the parent trees, are almost always dried up and destroyed before they are four months old. Hence it is that a section of country once stripped of trees and shrubbery, in our State, always remains naked. Once a prairie, always a prairie, until art comes to the assistance of nature. Hence it is that wheresoever our forests have been cut down and cleared away, allowing the rays of the sun to fall directly on the soil, so few young trees, or trees of the 'second growth,' are to be found."

This quotation contains some remarkable statements and admissions by one who is a citizen of the section described; but the statements are true, and the warnings therein given are for the best interests of his State, and should be well pondered, not only by the legislators of California, but also by our national statesmen.

Strike out the local names from this quotation, and almost every statement in it will apply with equal force to the entire Rocky Mountain region. So far as I have seen this section, the distribution of the forests is similar to that of California; they are isolated, found upon the higher mountain groups and ranges, and surrounded by broad, timberless spaces. As is well known to all who have any knowledge of the West, the plains which lie along the east flank of the great range, stretching eastward toward the Mississippi, are almost entirely treeless, the narrow fringes skirting a few of the streams not being of sufficient importance to be taken into consideration. This belt, which varies in width from two to four hundred miles, extends from the British possessions on the north to Mexico on the south, a distance of over twelve hundred miles, and includes an area of about four hundred thousand square miles. The lumber for every house built upon this broad space must be transported from one side or the other; so with every railroad-tie, timber for fencing, and for all the purposes where timber or lumber of any kind is required, unless it is cultivated and grown in artificial groves and forests.

New Mexico also presents a very large treeless area. Around the sources of the Pecos, along the eastern and southern rim of San Luis Valley, on the Mimbres and Guadalupe Mountains, and in the northwestern part of the Territory are found the principal forests affording valuable timber, while the rest of its area is generally without forests or trees of any value except for fuel. Fortunately, the forests are generally in the vicinity of the narrow agricultural areas, and in some instances the trees are large and fine, making good lumber; but most of the older towns and villages have to procure their lumber and fuel at a considerable distance.

Colorado is a comparatively new Territory, and its mountains afford

a large forest area, but even here it is somewhat difficult to obtain it, transportation for a considerable distance being necessary to supply the demands of the agricultural population. And the rapid consumption for building, railroads, mining, and other purposes is rapidly sweeping away the more accessible portions of the mountain forests. And here, as in other parts of the mountain region, fire is playing sad havoc with the arborescent covering of the mountain side.

The principal timbered sections of Wyoming are those along the southern boundary of the Territory, and in the extreme northwestern corner; large tracts of country, even within the mountain districts, as Laramie Plains, the Green River Plains, and Sweet Water Country, being almost entirely timberless. Utah has no important forests, except those found along the higher portions of the Wahsatch Range, the entire Salt Lake Basin furnishing few spots covered with forests of any value for timber or lumber. The northwest part of Montana contains a considerable area covered with valuable forests, which will afford excellent lumber, but which can be made available only to a limited district until penetrated by railroads, by which it may be transported to those sections which do not possess it.

But to say the best we can in this respect, a population of this part of the West equal to that in California will, at the present rate of destruction, soon strip the accessible forests of their valuable timber. And unless some method of preventing the present wanton destruction can be adopted, the supply will be cut off much sooner than anticipated; for, as stated in the quotation made, this destruction increases in a much larger ratio than the increase of population. And not only is this true if we limit our calculations to that which is applied to some useful purposes, but the destruction by fires, and that which is without any equivalent benefit, also increases in the same rapid proportion. In traveling through the mountain districts I was surprised at the large number of burned streaks which I observed. In some places we would not travel more than a mile or two without seeing either to the right or left a blackened belt stretching up the mountain side. If these spots would again be covered by a new growth the result would not be so disastrous; but as has been truly stated in the quotation, this is not the case, for when once the forest covering is destroyed, it is never restored, but remains forever bare. Whether this be wholly due to the climatic conditions or not, I do not know, but there are some reasons to believe that even where undisturbed by the hand of man the forests are gradually disappearing under the influences of natural causes.

The smooth and rounded hills in parts of Wyoming, Utah, Southeast Idaho, Southern Montana, and other parts of the Rocky Mountain region, have occasionally here and there a few trees which have every appearance of being the remnants of former forests. These hills bear unmistakable evidence of having been worn down by the action of the atmosphere, water, ice, snow, &c. The *débris* which has been worn down has covered up the former ruggedness of their declivities. This is so apparent that in many places its course can be traced down the sides along the graceful curves to its termination in the valley. But where the original rugged declivity has resisted this action there almost invariably forests will be seen. I have, therefore, come to the conclusion that the forests of the Rocky Mountains, as a general thing, are decreasing from natural causes, and I base my conclusions on the following grounds:

First. The wearing down of the mountains and hills; the *débris*, as it descends destroying the forests on their sides. At Pleasant Valley, (where the stage-road from Corinne to Helena crosses the range,) in

the basaltic cañon, this action even now appears to be in process, many of the blocks of stone having recently been loosened and rolled downward, carrying with them the pines, which may yet be seen. Here every stage of the process can be distinctly seen.

Secondly. In many places, as at the last-mentioned point, at the head of Black-Tail Deer Creek, along the head-waters of Sweet Water, the largest trees appear to be dying without any apparent cause, no evidence of fire being visible.

Thirdly. With the exception of two or three points, when the forest is once destroyed it never renews itself. At one point west of the range, on the road from Helena to Deer Lodge, I noticed a grove of young pines or firs, which were growing up on what appeared to be a burned district. At one or two points in the interior of the mountains, back of Denver, I noticed the same thing; also on the Raton Mountains. But the reverse is not only the general but almost the universal rule throughout this immense extent of country. Add to this the immense destruction by fire and the wanton destruction by human hands, and the prospect for timber in this section in the future is not very flattering. Unless there shall be some remarkable change in climatic agencies this decay must go on, as man has no power to prevent it; he may cease the destruction occasioned by his own negligence and wantonness, but he cannot stop the process on the mountains.

The late severe snow-storms (January, 1872) are somewhat remarkable. I have not obtained the particulars in regard to them, but if the newspaper reports are correct, they indicate the possibility of reacting climatic influences, which it would be well to study with care.

But our only reasonable hope of a change in the amount and distribution of moisture and a supply of timber is through the planting of forest-trees. Each Territory and State within the area under consideration should take this matter in hand, and by means of proper laws or premiums carry the planting of trees parallel with the settlement of the country. And directly connected with this matter is the want of hard wood in the entire portion of the United States west of the one hundredth meridian. I learn, to my great astonishment, that there is no hard wood suitable for wheelwright purposes, or for the manufacture of agricultural or other machinery, to be found on the western coast of North America, from the Arctic Ocean to the Isthmus. Whether this is correct or not I am not able to state, but I am satisfied it is true within the limits of the United States. All the material of this kind which is used even in making wagons anywhere west of the ninety-ninth or one hundredth meridian to the Pacific has to be brought from the Atlantic States. Now, if anything can be done to relieve this want, surely it would be of great benefit to future generations if of a permanent character. It is probable that no wood can be grown in this dry district of a tenacity equal to that grown in the rain-moistened districts of the Atlantic slope; but it is possible that such as will be adapted to all ordinary purposes may be produced, and the experiment is one that is worth trying.

The industrial agent of the Kansas Pacific Railroad is trying the experiment of growing forest trees on the plains without irrigation. It is to be hoped that this will not be given up until it is thoroughly tested; and I would suggest that although the experiment may not succeed along the whole length of the belt across the plains, yet it is of vast importance, should it fail in part, to know how far west it is possible to encroach upon the plains. If an inch can be permanently gained by the first experiment, an ell may be gained by perseverance.

Perhaps it will not be out of place for me here to make a suggestion in regard to a matter which deeply concerns the future welfare of the western half of the United States. As I have frequently stated, and as is now pretty generally known, irrigation is indispensable to cultivation of the soil throughout (with some very limited exceptions) all that part of the United States west of the one hundredth meridian. We also know from the history of those countries where irrigation is extensively practiced that it is absolutely necessary that the State shall take more or less control of this matter, upon which its prosperity, and, in fact, perpetuity rests. We may therefore predict, with confidence, that the day is not far distant when the States and Territories in the district where irrigation is necessary will have to take absolute control of the system of irrigation or keep a watchful eye over it and guard it well by laws, regulations, restrictions, &c.

As the development of the agricultural resources of these States and Territories and their prosperity depend upon irrigation and the extent to which this may be made available, therefore it is a subject of paramount importance, not only to those sections but also to the General Government. Unless proper and efficient steps are taken at an early day to adopt the best system of regulations, which will be adapted to an increased population, when the necessities demand such action in the future, it will cause much difficulty and inconvenience to lay aside one system and adopt another. This is, therefore, a matter well worthy the consideration of our national legislators while the Territories remain their wards; and if they can place these on the right footing now, it will greatly tend to accelerate their growth and prosperity. But the question is asked, How are they to do this? Is it possible for them to do this in accordance with their constitutional powers and without undue expense to the National Government? I am of the opinion there is a method by which this can be done, and I herewith submit the plan in a few words.

Let the General Government grant to the States and Territories in the region where irrigation is necessary—say, for example, all lying west of the one hundredth meridian, or perhaps the ninety-ninth, every alternate section of public land, with the condition that it be devoted entirely to the construction of irrigating canals and carrying on a system of irrigation. And the law making such grant should expressly reserve water privileges to those who may settle upon and occupy the remaining sections. By expressly providing that these lands should be applied solely to this purpose, it will be apparent to any one what an immense impetus it would give to the development of the agricultural resources of this section. All of the available water would thus be brought into use, and the reserved lands would also much sooner be brought into demand, as they would be as much entitled to the benefit of this measure as the lands thus granted. And in order to secure the grant from any improper diversion from the object contemplated in the grant, the law should provide that the States and Territories should refund to the General Government the value, at the minimum price, of all lands which the legislatures of these States and Territories should appropriate to any other purpose. The law should further provide that the grant should not include any portion of the reserved lands in lieu of those which might be occupied at the time of its passage, but should include only those employed. It should also provide that these State and territorial governments should not use any of the proceeds of these lands so granted for the payment of officers and other expenses of such registers, receivers, &c., as would necessarily have to be incurred in the

sale, &c., of these lands, but should limit the application of the funds arising under this grant to the expenses belonging strictly to the system of irrigation. This should not apply of course to mineral lands, and a special provision may be made in regard to the timbered lands on the mountains which are not adapted to agricultural purposes. One-half of these might profitably be granted, with the provision that, as a return therefor, it should be the duty of these State and territorial governments to guard and preserve the forests on those lands not thus granted.

There would be some difficulty in regard to the survey of these mountain lands, but here the division need not be limited to alternate sections, but might be by townships, or in such a manner as the Commissioner of the General Land-Office might ascertain to be most practicable.

I think it cannot be denied that such a plan would result in more permanent benefit to these sections and to the General Government than any other which can possibly be adopted. It would at once prepare the way for the introduction of the best possible system of irrigation, and prevent the inconvenience and trouble which will hereafter arise when the introduction of such a system becomes absolutely necessary. It would rapidly bring into use the lands which require such extensive canals that individuals will not at present undertake it. There are millions of acres on the broad plateau bordering the Arkansas, Rio Grande, Plattes, Snake, Missouri, and other rivers which might be rendered excellent agricultural lands if an enlarged system of irrigation could be inaugurated. But individual effort is inefficient for this purpose. And though the granting of lands to railroads may partially accomplish this, yet it is evident that it falls infinitely short of that result which would be brought about by the system here proposed.

I submit these thoughts with the earnest request that you will give them such consideration as you think they merit. The object which the plan is proposed to accomplish I know to be one which you have long cherished, and for which you have so many years labored, and to which you now look forward with an earnest hope.

CHAPTER II.

THE GREAT BASIN.

As I have already given, in a former report, a description of the various valleys and arable tracts in Utah, I shall at present confine myself to a general view of the principal geographical features of the Great Basin, concluding the portion devoted to the Territory with a more minute account of that section visited in person the present season.

I use the term "Great Basin" in contradistinction to that of "Salt Lake Basin," to include that immense area lying between the Wahsatch Mountains on the east and the Sierra Nevada Range on the west, embracing the western part of Utah and the entire State of Nevada. In shape it is something like an ancient shield, the broad end being to the North, the southern extremity rounded to a point, its extreme width about 350 miles and its length north and south 300 miles. Having no outlet for its waters, by which they may be carried to the ocean, it forms an isolated and, as might be inferred from this fact, a somewhat peculiar district.

Although a basin in fact so far as its water-drainage is concerned, yet its surface does not sweep down from the surrounding rim to a central depression, but, on the contrary, its areas of greatest depression are to be found near the borders, especially along the eastern and western sides, while its central portion reaches a much greater elevation, and is broken into a series of detached ridges. This will be seen by an examination of the elevations along the line of the Central Pacific Railroad. For example, at Brigham Station, on the border of Salt Lake, it is 4,220 feet above the level of the sea, while at Pequop, the next station west of Toana, it reaches 6,184 feet; from this it again gradually descends to Desert, the second station east of Wadsworth, where it is only 4,017 feet, or about 200 feet below the level of Salt Lake. The highest ranges in it will probably exceed the greatest elevation here given as much as 1,500 or 2,000 feet. The elevations at the points of greatest depression in the southeastern and southwestern portions have not been accurately determined, but it is known that in the vicinity of Sevier Lake it is not more than 4,500 feet above the level of the sea. A comparison of these elevations with those of the broad mountain belt lying east from the Wahsatch Range to the Black Hills of Wyoming will bring out this feature more clearly and forcibly, and at the same time afford us a means of comparing the climate of the two sections, so far as influenced by elevation, in the same latitude. The highest point of the Union Pacific Railroad on the western side of this belt is at Wahsatch Station, 6,879 feet above the sea-level. The highest on the eastern side is at Sherman, 8,242 feet. The lowest point between the two is at Green River, where the elevation is 6,140 feet, or about 2,000 feet above the lowest level of the basin. Some of the intermediate ranges, as the Uintah Mountains, reach a height of 10,000 or 12,000 feet, and the peaks occasionally exceed 13,000 feet. That this difference in altitude must produce a considerable difference in the climate is evident. North the difference is not so great.

This depression below the general level is a fact of much importance in estimating the agricultural resources of this extensive interalpine region, as it indicates a very material moderation of climate. And that which might be inferred theoretically has been shown by extensive experiments to be true in fact, as can be seen from the list of the productions of Salt Lake Valley given in my last report.

MOUNTAINS.

The mountain features of this basin are somewhat peculiar, differing in some important respects from those of the sections lying east and north, and exerting a decided influence upon the channels of travel and internal commerce, and upon the lines of settlement and centers of population. The Wahsatch Range, which runs almost directly north and south near the one hundred and twelfth meridian, forms the eastern rim, and presents an immense terrace wall, bracing up the broad elevated table-land which stretches out eastward of it, and of which it may be said, with more than mere figure of speech, to form the western escarpment. It follows that its western slope presents a greater descent to reach the level of the lake than its eastern to reach the level of Green River. Except where cleft by the Ogden, Weber, and Provo Rivers, it presents a continuous ridge rising abruptly from the narrow plains, seldom sending out on this side foot-hills or slopes, but plunging abruptly down beneath the *débris* that presses against its surface. This

character is especially prominent opposite Salt and Utah Lakes. The western face, though rocky, does not present that jagged, rugose appearance so characteristic of portions of the Rocky Mountains, but is marked by deep and sharp furrows, down which the little streams formed by the melting snow rush with impetuous speed to the valley below. These little rills and mountain brooks, though but small in volume, not combining to form any extensive streams, are perhaps of more value to the pioneer settler than the larger ones. And in our estimate of the irrigable land of this western country, especially if we pass through it in the latter part of summer or in autumn, we are apt to overlook or underestimate their value. I am satisfied that while in some instances I may have overestimated the capacity of large streams, I have paid too little regard to the small ones. My attention was called in a special manner to this subject while camped near Ogden the present season. Our tents were pitched on the high ground to the northeast of the town, which, to one traveling along one of the usual highways, would appear to be entirely beyond the reach of irrigation, the elevation being, as appears from the observations of Mr. Schönborn, the topographer of the expedition, over 300 feet above the level of the lake, and about 300 feet above Weber River at the railroad depot. Yet even here I noticed around and for some distance above camp several irrigating ditches well filled with water, from one of which we obtained a supply for camp use. I found, upon examination, that these were supplied with water from little streams running down the indentations in the mountain side to the north of us, fed by the patches of melting snow resting among the crevices along the summit. Although within two miles of the base, and the hot sun shining squarely against what appeared to be a bare and naked rocky wall, we could detect no stream flowing down it. Not until we had approached to the very base could we discover the silvery thread winding its way down among the bowlders and little fringe of bushes that lined its pathway. This stream furnished water sufficient to irrigate and supply the wants of a moderate sized farm. Multiply this by tens of thousands and we will have some idea of the importance of these minor and annual streams which generally pass unnoticed except by those immediately interested in them.

Passing to the interior of the basin, whether moving round the north or south end of the lake, we shall find a succession of "long, abrupt, detached, parallel ridges extending in a north and south direction." And this holds true not only on the eastern side, or Salt Lake Basin proper, but also throughout the greater portion of Nevada. That such is the case in the southeastern part of this State is expressly stated in the report of the expedition under Governor Blasdel to Pahranagat. Baron Richthoren alludes to the same character of the ranges in the southwest. These ridges are separated by intervening valleys of various width, and even where the valleys expand into broad open plains, as in the central and western part of Utah, their boundary walls retain the same general course. The valley of the Humboldt might, at first sight, appear to form a remarkable exception to this rule, but a closer examination will show this to be a mistake; for the greater part of its course it is formed by a series of openings through these ridges and across the intervening valleys. That this is true is clearly shown by the direction of the tributaries that flow into it. This uniformity in the direction of these minor ranges was noticed by Captain Stansbury, who states that even the northern rim of the basin partakes of the same character. "The northern rim of the Great Basin, or the elevated ground which divides it

from the valley of the Columbia, does not consist, as has been supposed, of one continuous mountain range which may be flanked, but of a number of long, abrupt, detached parallel ridges extending in a north and south direction, and separated by intervening valleys, which constitute, as it were, so many summit levels, whence the waters flow north on the one side into the Columbia, and south on the other into the Great Basin." And in this opinion he is quite correct, for in passing from Cache Valley to Marsh Valley, the one lying south and the other north of this rim or divide, we found the two so united as to be continuous, but elevated at one point by a kind of broad cross-ridge which acted as a divide between the waters. I also know that such is the case with the Malade Valley.

In Utah this direction of the valleys holds good with a remarkable uniformity. Cache, Malade, Blue Spring, Hansee Spring, Jordan, Tooele, Tintic, San Pete, Rush, Lone Rock, and Upper Sevier Valleys all maintain this course almost direct, while the two parts of Salt Lake conform very nearly to it. From the head of Malade River to Utah Lake is one continuous valley, varying less than five degrees from a north and south course. Antelope and Frémont's Islands and Oquirrh Mountains lie in a direct line with the course of the promontory which separates the northern arms of the lake. Without any reference to this law which seems to govern the hills and valleys, I colored, upon a large map, the arable tracts of the Territory so far as at present known, especially those in which settlements have been made, when I was astonished to find that from the thirty-ninth parallel to the northern boundary almost every tract so colored would be included in a strip along the one hundred and twelfth meridian not exceeding fifty miles in width; Tooele, Rush, and Weber Valleys being the only exceptions. Another singular evidence of the force of this law which governed the formation of these ranges and valleys is shown in Cache Valley, which maintains the same direction, though closed at the lower end by a cross-range of broken hills which shoot out from the Wahsatch Range, and crossed at the north end in a diagonal manner by the valley of Bear River. A similar feature seems to govern the valleys of the western side of the basin. Baron Richthoren, speaking of the Washoe Mountains, says that they are separated from the steep slope of the Sierra Nevada by a continuous meridional depression, marked by the deep basins of Truckee Valley, Washoe Valley, and Carson Valley. Though irregular, a general direction may be traced in the summit range from north to south, where it slopes down to a smooth table-land, traversed from west to east by the Carson River, flowing in a narrow crevice, beyond which the Washoe Range is protracted in the more elevated Pine-Nut Mountains.

Notwithstanding this uniformity in the direction of the ridges and valleys, it exerts but little influence on the few leading streams, but, on the contrary, directs the course of all the minor streams. That it must have more or less influence upon the lines of travel and traffic, and the localities of the settlements of the Territory of Utah, is evident. A single railroad line from Corinne or Brigham City, in the north, to Saint George, in the extreme southwest, would have the principal agricultural areas strung so closely along it that a day's drive with a team would reach it from almost any settlement likely to be made for some years to come, (the chief exceptions being those already named and those lying north of its terminus.) It is, therefore, easy to predict where the chief highway of this Territory will be.

RIVERS AND LAKES.

The rivers of the basin are small, and, so far as the volume of water is concerned, of small importance, but in other respects play a conspicuous part in the development of the country. The principal ones are the Humboldt and Carson, in the western area, and the Bear and Jordan Rivers, in the eastern part. Sevier and Beaver Rivers, in the southwestern part of Utah, are considerable streams as compared with others of the section; but as little is accurately known in regard to them, I pass them without any special notice. Weber River, on account of its position, and as forming a gap through the mountain, is important. Provo (or Timpanogas) may be considered as a tributary to the Jordan.

As a list of the principal valleys of Nevada will be appended to this report, with a short notice of the agricultural resources of each, I shall omit further reference to that State at present, except the bearing the Humboldt River and Valley have upon the travel and commerce of the basin. This stream, rising in the northeast part of Nevada, runs a little south of west for about three hundred miles, where it suddenly disappears in what has been very significantly and appropriately termed the "Humboldt Sink," on the extreme western side of the State. Though a little stream of but few yards in width at its widest point, winding its way down the gradual descent through narrow valleys of a monotonous uniformity that soon tires the most enthusiastic traveler, wholly inadequate for navigation of any kind, yet it possesses an importance not to be overlooked. Its valley forms a natural channel for the great interoceanic highway, furnishing a natural and, we might say, the only, easy pathway and water-supply through a barren region of mountains and valleys for three hundred miles. This is certainly a consideration of no small moment, for it renders it really more valuable to the nation and the world than if, without this, it were navigable from head to mouth. Small as it is compared with the treeless ranges of hill and plain on each side, yet it will furnish the means of forming at least a narrow line of green fields through this comparatively barren section; for, to say the best we can of this region, although, perhaps, affording moderate grazing fields, yet outside of the immediate bottoms of the few streams it has a barren and uninviting appearance. This line assumes still more importance when we take into consideration the large mining area on each side, especially south, to which it forms the base of travel and commerce; and the prevailing direction of the ridges and valleys, before alluded to, lend additional force to this statement. It must ever be the chief axis of inland commerce and travel for the western portion of this great basin, and, consequently, a link in a through transverse line. Other lines of railroad may, and probably will, hereafter traverse the country north and south of this, but not so closely as to do away with its importance. Human genius and energy may make a pathway through the most rugged portions, but nature has prepared but one transverse channel in this region; longitudinally (north and south) there are many. But while the river is thus intimately connected with the development of the material resources of the country, on the contrary, the reservoir into which it pours its waters possesses no other than scientific interest—simply a marshy spot in a sandy plain, the extent of the water surface governed by the supply and capacity of the sands to drink it up and the atmosphere to evaporate it, the two latter generally being in excess of the former.

Bear River, the largest tributary to Salt Lake, takes its rise in Utah, near the southwest angle of Wyoming. After winding its way north-

ward through the Wahsatch Mountains, about one hundred and fifty miles, extending even into the southern limits of Idaho, suddenly bends its course completely round, and flowing southward, pours its waters into Bear River Bay. As affording a supply of water for irrigating large areas of land in Cache and Malade Valleys, it assumes an importance of no little moment; but throughout its entire course, from its head to where it enters Cache Valley, (with the exception of a few miles where the railroad traverses it, and where the coal-mines are opened,) it exerts but little influence in the development of the country. Its volume of water is too small to admit of navigation; its course is too tortuous to be followed any great distance by any one line of travel; and its valley is too narrow and too closely hemmed in by rugged mountains to be of any great value as an agricultural section, yet not wholly without interest in this respect. As a means of conveying timber down from the mountains to the railroad and other accessible points, it may become a valuable accessory.

Weber River, though small, is remarkable as affording a gateway directly through the Wahsatch Range, Echo and Weber Cañons presenting, as is well known to all who have traveled on the Union Pacific Railroad, some of the grandest scenery in the West.

The Jordan forms an outlet for the fresh water of Utah Lake, and, running north some forty or fifty miles, empties into Salt Lake at its southeast angle. Insignificant in size, too small to be navigated, yet unlike the Oriental Jordan, from which it derived its name, it is of other value than simply a watering-place for thirsty man and beast. It and its tributaries afford water for irrigation, as shown in my last report, to an area capable, if properly and thoroughly cultivated, of supporting a population greater than the entire population of the Territory at this time.

The Provo, (or Timpanogas,) rising back in one of those mountain centers found in the mountain regions, rushes down through a narrow cañon, which cleaves the range at this point, and pours its waters into Utah Lake. In passing I would call attention to this mountain nucleus, situated about latitude 40°.30, longitude 111°, and culminating in Reed's Peak. This is doubtless formed by the junction of the Uintah Mountains with the Wahsatch Range. Here, within a small area, all the leading rivers of Salt Lake Basin proper take their rise, viz, Bear, Weber, and Provo; also the Uintah and White Rivers, which flow to the east and enter into Green River. The volume of water in the Provo is probably equal to any other belonging to the Salt Lake water system, except Bear River; and as its descent is very rapid it affords the means of irrigating all the table-lands lying in the vicinity of its exit from the mountains. It will afford excellent water-power for driving mills and machinery, and, being on the margin of the lake, must become of great value in this respect.

Sevier River rises in the southwest part of the Territory and runs a little east of north between two ranges of the Wahsatch Mountains for one hundred and fifty miles or more, when it breaks through the western rim of its narrow basin, and, turning southwest, flows into Sevier Lake. But as I have not visited this river I cannot speak very confidently in regard to its importance and the bearing it is likely to have upon the development of the country. Very little appears to be known in regard to the lake into which its waters flow. Mr. Smith, one of the members of the topographical corps of the present expedition, passed around its southern margin a few years since. Although he did not stop to make an examination, he saw clearly that it was a lake, and

not a mere sink or marsh, being surrounded by a low growth of bushes. This would indicate that its waters are salt. The little streams that flow down the western slope of the range, (improperly represented in most maps as flowing east through the mountains,) and sink in the plains during the summer and autumn, probably reach the lake, by one or two channels, in the early part of the season, when fullest, as their general course, after reaching the plain, is known to be to the northwest.

From Weber River to the creek that flows into Salt Lake City, about thirty miles in a direct line, only two or three small rills are to be seen; but from the latter to the south end of Utah Lake some ten or twelve moderately sized creeks flow down from the Wahsatch Range, a list and description of which can be seen in my former report. The range on the west side of Jordan and Utah Valleys gives rise to none worthy of note, two little rills from the Oquirrh Mountains being all I saw.

GREAT SALT LAKE.

Although its waters are strongly saline and brackish, unfit for use to man or beast, and its depths, so far as known, undisturbed by finny tribes, yet the Great Salt Lake is the chief object of interest in the physical geography of the basin. Its dark-looking, (though really transparent,) heavy waters when not broken into rugged waves by storms, resting quietly, its surface reflects the shadows of the ranges that rise up on either hand, giving the scene a look of quiet solitude that all the hum of business along its shore is unable to dispel. The dark-brown wall of the Wahsatch, until the rising sun has reached its zenith, sends down a heavy shadow which adds intensity to this feeling. This perpetual somberness, it would seem, must, to a greater or less degree, impress itself upon the mind of the resident who makes the rural districts long his home. One thing which adds to this somewhat peculiar somberness is the clear, transparent atmosphere, which renders vision telescopic, bringing the mountain-walls close around us.

Although the shores of the lake have been inhabited for twenty years, and numerous scientific travelers and parties have traversed this region, and the great railway, from the Atlantic to the Pacific, passes along its margin, yet little is known in regard to it more than its mere outline as originally mapped by Captain Stansbury. Its western coast is known to the public only through the interesting narrative of Captain Stansbury; and although some analyses of its waters have been made, yet comparisons from different parts and different depths have so far been entirely neglected, and up to this hour little or almost nothing can be stated positively in regard to animal life in its waters. Numerous species of small fishes of *Articulata* and *Mollusca* are to be found in the streams that flow into it, and traced to its very margin; but how far into the lake these extend is not known. That ducks and other waterflowls gather food along its shore I know from personal observation. I have also seen Bear River Bay almost covered with gulls; and Stansbury brings this fact prominently forward in one of his figures of Gunnison Island, which lies on the western side at a distance from the influx of fresh water. Although Captain Stansbury thinks these birds obtain their food entirely from the fresh-water streams, yet he speaks of finding a blind pelican in a "sleek and comfortable condition." Although these birds may congregate here for the purpose of rearing their young, yet this seems scarcely adequate to account for the presence of such numbers. The only analysis of the waters of the lake that I am acquainted with is that made by Dr. Gale and recorded in Captain

Stansbury's report. It gives the specific gravity, 1.170; solid contents, 22.422 out of 100 parts. The solid contents, when analyzed, gave the following components:

Chloride of sodium	20. 196
Sulphate of soda	1. 834
Chloride of magnesium	0. 252
Chloride of calcium	A trace.
	22. 282
Loss	0. 140
	22. 422

The specific gravity as here given corresponds exactly with the mean of eight different analyses of the waters of the Dead Sea, which is largely above that of the water of the ocean, (1.0278.) The solid contents of the water of the Dead Sea, taking the mean of the eight analyses,* before mentioned, is but 21.077, or 1.345 less than that of Great Salt Lake. This analysis shows clearly, as confirmed by practical experiments, that here can be obtained an abundant supply of salt for all the wants of this entire region, the percentage in the water being unusally large.

When we remember that all the water which flows into the lake is fresh, a somewhat puzzling question arises as to the source of such an abundant supply of saline matter. But the numerous and extensive saline incrustations at various points on the surrounding shores, left by the drying up of the winter marshes, show very clearly that some portion of the earth is saturated with this ingredient. But as an investigation of this subject does not belong to the scope of this report, let us turn to that most interesting feature of the lake, the fact that although receiving the waters of various streams, yet it is without any visible or even supposed outlet, its influx of water being disposed of entirely by evaporation. A very natural inference is that the level of the lake must vary with the amount of water discharged into it by its various tributary streams. In the spring, when the streams are highest, the humidity of the atmosphere greatest, and consequently evaporation slowest, we would presume the level of the lake is higher than in the latter part of summer when the tributaries are low and the atmosphere dry. What the difference of the level is between these extremes I do not know, nor am I aware that any observations have been made for the purpose of ascertaining, but I am inclined to think it far less than might be supposed. The rise of the level of the lake within the last eight or ten years, I am satisfied, can have no connection with an increased influx of water, but is owing entirely to some other cause.

The shores being quite flat, a variation of the level of the lake can be easily perceived, and hence the fluctuations if considerable would be observed. But there is probably a very potent reason why these variations are very slight; the evaporating influence is probably in excess of the normal amount of water flowing in, but is counteracted by the extreme saltness of the water, hence the spring excess of water does not produce the effect on the status of the lake that might be expected. In other words, the lake would dry up and become simply a water-sink as that of the Humboldt, if it were not for its saltness. The material

* Smith's Bib. Dic, III, 1183c.

of which the bottom of the lake is composed also probably has influence in this matter.

According to my calculation, from all the dataI have at hand, the surface-area of the lake is about one thousand nine hundred square miles Comparing this with some approximate estimates I have made of the volume of water in the principal streams emptying into it, I do not think the entire flow for twenty-four hours, if there was no evaporation, would raise the surface more than one-fiftieth part of an inch, even when at the usual spring standard. In the summer this would not amount to more than one-hundredth part of an inch. That the evaporating power of the atmosphere is far in excess of this amount of water in the summer time is evident to any one who has observed the rapidity with which shallow pools are dried up. The instrumental test, so far as it has been made, shows the atmosphere in summer to be exceedingly dry. While encamped on the margin of Bear River Bay, June 10 to 13, Mr. Schönborn found the difference between the wet and dry bulb to be from 24° to 28°. The imperfect record of the wet bulb in Captain Stansbury's report does not show this difference, but his observations do not extend into the summer months, reaching only to April 19. Imperfect as this record is, it reveals one important fact, that during the winter months the difference between the wet and dry bulb is very small, not exceeding four or five degrees, but gradually increases as the season advances; the greatest difference given being 17°.

UTAH LAKE.

This beautiful sheet of pure, fresh water is triangular, its three sides closely margined by mountains. Its base, which is the western side, extends from the exit of the Jordan to the southern extremity of the lake, and is about twenty-two miles in a direct line. Its apex points eastward and extends into the somewhat abrupt bend of the Wahsatch Range at this point. A direct line from the apex, near Provo City, to the base, is about twelve or fourteen miles. The inclosing sides of this angle are about equal in length, each being some sixteen or seventeen miles direct.* Its surface area is probably about one hundred and thirty square miles. Although the Jordan during the spring and first summer months sends down a considerable volume of water, I am satisfied that it is much less than the amount received by the lake. But as I visited it in the early part of autumn I can speak positively only as to that season of the year. From the observations then made I am decidedly of the opinion that the Provo River alone brought in more water than the Jordan carried off, leaving this surplus and that furnished by six or seven small creeks to be disposed of by evaporation. But it is evident that the relation between supply and evaporation is the reverse of what it is with Salt Lake; for as the Jordan never fails, (so far as I am aware,) the supply must always be in excess of that carried off by evaporation. Its waters are well stocked with fish and other aquatic forms of life.

CLIMATE.

As but very few meteorological records have hitherto been kept in this basin, and these but for a few years only, and very irregularly, we can only give an approximation to the means of temperature and rain-

* Air-lines are to be understood in estimating these distances.

fall for the year and months. Yet even these are of great interest, as they furnish cumulative evidence in support of the opinion already advanced respecting the climate of Salt Lake Valley as compared with the elevated regions lying east of it.

The following extracts from the registers of Camp Douglass, near Salt Lake City, and Fort Bridger, for the year 1870, will serve as a basis of comparison:

Month.	Camp Douglass.				Fort Bridger.			
	Thermometer.			Rain-fall.	Thermometer.			Rain fall.
	Mean.	Max.	Min.		Mean.	Max.	Min.	
January	31.74	62	11	1.53	20.75	43	—24	.82
February	36.43	58	17	1.44	25.24	44	— 8	.00
March	34.08	65	3	4.57	25.71	53	—11	.88
April	49.91	79	21	3.40	45.38	68	20	.70
May	58.53	85	34	2.10	50.55	75	27	1.20
June	68.10	94	34	.73	59.38	83	30	.40
July	76.45	96	54	1.48	67.71	87	46	.24
August	71.54	95	44	.45	61.42	87	27	.46
September	61.70	82	45	.45	51.42	80	21	.18
October	52.90	84	30	.85	41.84	70	16	.08
November	49.71	65	28	.68	39.98	56	8	.05
December	27.03	48	4	.41	19.26	48	—10	.57
Yearly mean	51.51			Total.. 15.10	42.05			Total .. 5.58

These two stations, by air-line, are not exceeding one hundred miles apart, the latter being about half a degree north of the former, and over 2,000 feet higher.

An examination of these tables shows a constant difference that is somewhat remarkable; the monthly means, maxima, and minima, with the single exception of one maximum, (where the two are the same,) of Camp Douglass being higher than those of Fort Bridger. The difference between the monthly means is never less than 4°.5, and never more than 13°.7, the average for the year being 9°.46. A comparison of the extremes shows a greater difference, but this probably arises in part from the different methods by which they were obtained, those of Camp Douglass being only the extremes at the times of observation, while those of Fort Bridger were obtained by a maximum and minimum instrument. Yet even these columns indicate a corresponding difference, that between the maxima varying from 0 to 19, averaging for the year 9.92, or less than a half-degree more than the average difference for the year between the monthly means. The minima cannot properly be compared, as those of Camp Douglass do not give the extreme cold of the night, or intermediate hours between observations, while those of Fort Bridger do.

A comparison of the seasons is quite interesting. To show this at a glance, I append the following table, with a column of differences:

Localities.	Spring.	Summer.	Autumn.	Winter.	Maximum.
Camp Douglass, (therm. means)	47.51	72.03	54.77	31.73	96.00
Fort Bridger, (therm. means)	40.55	62.84	43.08	21.78	87.00
Difference	6.96	9.19	11.69	9.95	9.00

December shows the lowest monthly mean, and July the highest, at both places.

The record of Camp Douglass indicates a climate very favorable to agriculture, the mean of the five months April, May, June, July, and August being 64.91, and the thermometer at no time, from May to September, inclusive, falling as low as the freezing-point. Other meteorological data which I have at hand, although fragmentary, corroborate this, and, as a means of reference, I present a summary in the following table, calling attention to the fact that the records were not all kept at the same point, but all in Salt Lake Basin, and therefore can only be considered valuable as indicating the climate of the basin, (the lake basin proper,) taken as a whole:

Localities.	Spring.	Summer.	Autumn.	Winter.	Yearly.
Camp Douglass	47.51	72.03	54.77	31.73	51.51
Great Salt Lake, (Blodget)	51.7	75.9	....	32.1	....
Camp Floyd, (Disturnel)	47.17	75.65	48.44	23.32	48.65
Wanship, (Agricultural Report, 1868)	....	69.7	(Oct.) 54.7	21.87	....
Salt Lake City, (ditto, 1868 and 1869)	....	72.32	....	27.5	....
Coalville, in the mountains, (ditto, 1869)	45.9	69.2	48.9	....	....
Mean	48.07	72.47	51.70	27.30	50.08

The record kept by Captain Stansbury while in Salt Lake Valley embraces but a part of the year, as follows: January to May, inclusive; parts of June, July, and August; and a few days in September and December. In this the maximum is, August 10, 3 p. m., 98°; minimum, February 3, 8 a. m., 6°, while at 11 p. m. of the previous day it was 8°.

The only record of rain-fall within the basin that I have is that of Camp Douglass, which is given in one of the foregoing tables. There is some doubt in regard to the reduction of the snow, which materially lessens the value of this column, so far as the winter months are concerned. I will simply call attention to the fact that this gives for the four growing months, April, May, June, and July, a total of 7.71 inches, which is but 0.37 above my estimate in my last report of the general average for spring and summer.

FORESTS.

The Wahsatch Range is covered with a moderately heavy growth of pines and firs, but these are confined chiefly to the upper half of the mountains, leaving a wide border along the base uncovered. The Oquirrh Mountains, the range west of Utah Lake, and the Promontory also contain considerable quantities of pine timber. But as a general thing, the timber within the rim of the basin, south of the Pacific Railroad, is small. On some of the ranges north a better quality is found, but it is not very abundant at any point. In regard to the forest growth west and southwest of the lake, I know very little.

CHAPTER III.

NORTHERN PART OF SALT LAKE BASIN AND THE SNAKE RIVER PLAINS.

Having in my last report given short descriptions of the principal valleys of Utah, with rough estimates of their arable areas, will only

add the following in regard to the small section in the northern part visited the past season:

Weber Valley, which is drained by the river of the same name, is situated in the gap of the Wahsatch Mountains made by the river in its passage through them, and is on the line of the Union Pacific Railroad. The valley proper begins at Weber Station, and extends westward to the Devil's Gate, a distance of some eleven or twelve miles, varying in width from three-fourths of a mile to two miles. The land is good, and most of it can easily be irrigated, the supply of water being ample for this purpose throughout the growing season. At the west end of the valley, on the north side, there is a narrow terrace some 12 or 15 feet higher than the bottoms, and four or five miles long by half a mile or less in width. The mountains on the south side have some pine timber near the summit, sufficient for the use of the valley population, but, as is generally the case in this region, somewhat difficult to obtain. The mountains on the north side are mostly destitute of timber in the immediate vicinity of the valley. Grazing is tolerably good on the foot-hills and mountain slopes to the south. Wheat is the principal crop raised, though the other cereals, even some varieties of Indian corn, will grow. Such fruits as apples, cherries, currants, raspberries, strawberries, &c., can be produced.

The river, at the time of our visit, (June 1 to 9,) was quite full, being, at the point where the estimated measurement was made, about sixty feet wide and from one to three feet deep, flowing quite rapidly, at least four miles per hour.

Uintah Valley commences just below the mouth of Devil's Gate Cañon, and is in fact but a part of Salt Lake Valley, extending up into a bend of the mountains. It is, in other words, the broad pathway that Weber River has cut through the sloping plain of Salt Lake Valley. It continues to the vicinity of Ogden, a distance of some nine or ten miles, varying in width from a half to two miles, and all susceptible of irrigation. The fall of the stream through this valley is much more than would be supposed, judging it by the eye, being, according to the railroad survey, 220 feet in the ten miles, or 22 feet to the mile, which shows that the water can be carried up to the higher terraces which lie on the south side near Ogden. The rapidly increasing importance of this point will probably, ere long, cause irrigation to be carried on here upon a much larger scale than at present; for the soil is very rich, and every spot that can be irrigated will become valuable when the drawbacks to its settlement are removed.

The town of Ogden is situated along the escarpment of a terrace some 50 or 60 feet high, one part built on the lower level, the other part on the upper level. The soil of this terrace is a very light sandy loam, and when supplied with an abundance of water will produce very fine vegetables. The town is tolerably well supplied with water, chiefly, I believe, from Ogden Creek, which crosses the plain a little north of this place.

A number of shade-trees planted along the streets by the side of the ditches have grown steadily, until now some are over one foot in diameter, quite thrifty, and furnishing a very agreeable shade during the hot days of summer. There is, in fact, no other trouble to be experienced in growing forest-trees here than the planting and ditching for water, and this need not be supplied after they have had a firm and vigorous growth for three or four years. The cotton-wood, mulberry, locust, (*pseudacacia*,) Lombardy poplar, willow, and many other varieties can be raised without difficulty. I noticed in Salt Lake City locust,

ailanthus, and walnut growing finely near the ditches. Whether the hard woods, such as white-oak, hickory, beech, &c., could be grown to a size that would make them valuable is not known, but certainly it is of sufficient importance to induce the citizens or the territorial authorities to make a thorough experiment.

It may appear absurd to say that after you once enter upon the plains going west, you cannot find sufficient hard wood in that portion of the United States lying between there and the Pacific Ocean to make an ax-helve. Yet this is no great exaggeration. Go into the wagon-shops of San Francisco and Sacramento and ask the workmen there to tell you where they procure the timber for their hubs, spokes, fellies, tongues, axles, &c., and they will tell you from the East. I had supposed that here, or at least in Oregon, an abundance of suitable timber for wagons, agricultural implements, &c., could be obtained, but the oak and ash is not used, as it is unfit on account of its want of tenacity or "brashness." Traverse the entire Rocky Mountain region from Montana to the Mexican line, and this will be found true without any exceptions. The climate is incompatible with the production of such wood when left to the supply of moisture nature gives. What difference a more abundant supply would have I am not able to say; and though I have some doubts in regard to the production of timber adapted to these purposes, yet it should only be admitted after a fair and thorough trial had been made.

Perhaps it would be well for the General Government, under either the Agricultural Department, Commissioner of the Land-Office, or commanders of military posts, to make a trial in this direction at one or two important points in the West; for, if I am correct in the assertion made—and I certainly have no desire to misrepresent, but have made the statement after a somewhat careful inquiry—it is a matter of great importance to that section of our country.

From Ogden the level bottoms or lake-shore lands spread out north and west, forming a triangular area. Westward to the lake-shore is about twelve miles, and north to the "Hot Springs" about the same distance. At this latter point the arm of Bear River Bay and a spur of the mountain approach quite near each other, rendering the shore-level narrow. This triangular area contains about forty or fifty thousand acres, the greater portion of which is susceptible of cultivation, and is rich and productive. Already a large portion of it is occupied and under cultivation, and, although not farmed with that care required to bring forth its strength, yields remunerative crops. And notwithstanding the soil is a loose, sandy loam, which would seem to render it permeable by the extremely brackish water of the lake, yet where not absolutely covered with saline incrustations, this part of the shore-level can be cultivated within a short distance of the water's edge. Even the tongues of land which run in between the heavy saline deposits make very good farming land when irrigated. On some of these there are already considerable settlements, from one of which we procured our vegetables and a supply of excellent strawberries while encamped near the Hot Springs, where we remained three days waiting for some members of the party.

Not only do the cereals—including a tolerably fair variety of corn—grow well here, but fruits also, such as apples, pears, peaches, apricots, cherries, grapes, currants, strawberries, &c., can be raised in abundance and with comparative ease, the only drawback being occasional untimely frosts and the truly "hateful grasshopper."

It is the opinion of many of the old settlers that the climate is gradu-

ally growing milder. They found this opinion on the fact that when first settled it was almost impossible to mature the tenderer fruits, as peaches; whereas, at present, they experience but little difficulty in this respect. But this may be owing, in a great measure, to the strength acquired by the trees by age, and to a partial acclimation. And the same thing is doubtless true here that has been found true in California, that while the trees are young they require much more irrigation than after they have come into bearing; and depriving them of water probably renders them less liable to be affected by frost. It has been ascertained in California that orchards and vineyards produce better fruit and more certain crops without irrigation, after they have come into bearing, than with it; hence the practice of watering them is being generally abandoned.

From the Hot Springs to Brigham City there is a narrow strip of arable land, which, though ascending toward the mountains on the east, and being somewhat broken and irregular, yet can nearly all be irrigated from the little streams which flow down from the mountain. The soil is quite good, and appears to be especially adapted to the cereals and grass. Advancing northward toward Brigham City, the area widens as the shore-line of the bay bends westward.

Around Corinne, at the mouth of Bear River, and at the termination of Malade Valley, is a broad, level expanse, probably some ten or twelve miles wide east and west by fifteen miles long north and south. On this area there are some considerable tracts crusted over with saline or alkaline deposits. A portion of the area east of the river, which is much less than that on the west side, can be irrigated from Box-Elder Creek, which comes down from the northeast through Box-Elder Cañon. As suggested in a former report, from information received, for at that time I had not visited this valley, the level area around Corinne might be irrigated from Bear River by commencing a canal at the mouth of the cañon where the river bursts through the hills. A move is now on foot for this purpose, and a bill has been introduced into Congress to obtain a grant of land in aid thereof. I do not know the amount of land which can be redeemed by such a canal, but I judge not less than 50,000 acres, and perhaps as much as 75,000 acres. I crossed this tract the past season in both directions, and although there are some strongly alkaline spots, yet I believe there are none but which may ultimately be purged and rendered productive; and if properly irrigated the entire area may be rendered excellent agricultural lands. West of this, as we near the Promontory, there is an area of considerable breadth as desolate as can well be imagined. The portion which is not covered with white incrustations looks as though it had been swept over by a flood of some scalding chemical which had the power to annihilate every germ of vegetable life. I see no means of redeeming this gloomy desert belt, and I am inclined to think there is somewhere here an apparently inexhaustible source of this saline matter, so that even if there was water to irrigate it, it could not be purged of this matter so as to render it suitable for agricultural purposes.

All that portion of Utah north of Salt Lake and west of Malade Valley, so far as I have seen it, is generally barren, with no apparent means of irrigating to an extent sufficient to produce any useful crops. Whether artesian wells would prove a success here or not I do not know; but unless water can be obtained by this means, most of this section is doomed to sterility until some natural change shall produce a large annual rain precipitation.

Malade Valley, from the point where it connects with Bear River

Valley northward, is some twenty-five miles long and has an average width of six or seven miles. It is quite fertile and tolerably well grassed over, affording excellent pasturage. Stock-raising and the dairy business appear to be the chief occupation of the settlements that have been made here. Malade River, together with the little rills which flow down from the elevated ridges on each side, will probably be sufficient to irrigate most of the level land. There is one point near the upper end of this valley where the cattle appear to be subject to a fatal disease, arising from some local cause. Whether this is permanently the case or not I am unable to say. I noticed, in passing through this part of the valley, quite a number of dead cattle, and understood that ox-teams stopping here for a short time have sometimes suffered severely, but was unable to obtain any satisfactory information as to the probable cause of this. But even if this information is correct it is limited in area and does not apply to the greater portion of the valley, especially the lower half.

FROM SALT LAKE TO SOUTHERN MONTANA.

From the point where we left Salt Lake until we reached the southern boundary line of Montana, I shall confine my notes on the agricultural resources of this section to the immediate line of our route, as I obtained but very little information respecting the country either to the right or left. And perhaps I cannot do better than to give my original field-notes, which were generally written while the sections described were in view.

Leaving our camp near the Hot Springs, about ten miles north of Ogden, for the first five or six miles we traveled up the level shore of the bay, which, until we pass Willard City for a mile or two, is tolerably well settled. About Willard City the ground rises somewhat, and is more uneven and bouldery than usual in this valley. There are some good farms here, which slope off below the town toward the bay. A plain, generally level, extends around the curved shore-line of the bay, from our last camp to a point some distance west of Corinne, in a direct line, some twenty or twenty-five miles. Some areas near the bay and in the northwest part near Corinne, and one spot immediately west of Brigham covered with white saline incrustations were glittering in the clear sunshine as we passed. The mountains sweep around this area in a somewhat semicircular form, gashed here and there by complete or partial cañons. The hills on the north and northeast are beautifully rounded, smooth, and covered over evenly with grass and *artemisia*, here and there interrupted by little thickets of green bushes or areas of yellow composite flowers.

Brigham City, a small town of two or three hundred inhabitants, is situated near the mouth of Box Elder Cañon, on a ridge or terrace considerably elevated, which appears to be composed of a sandy soil mixed with coarse gravel, and covered, where not in cultivation, with *artemisia*. As we passed over this terrace, which is probably two hundred feet above the shore-level, I noticed irrigating ditches traversing it in various directions; the water is probably brought from Box Elder Creek. Here, turning suddenly around a long, elevated, and smooth terrace, we enter Box Elder Cañon, which extends through the mountain, in a northeast direction. Ere we descended to the level of the creek behind this terrace we had a splendid view of the country over which we had passed. Looking back we could see the entire Salt Lake Valley spread out before us as a grand panorama.

The sides of the cañon consist mostly of high, steep, but smooth rounded hills, with occasional spots where the rocks jut out from the surface. It is quite tortuous and narrow, affording only space for a wagon-road. The creek rushes through it with considerable impetuosity, and although rather small sends down water sufficient to irrigate a large area of land if properly husbanded. The ascent is somewhat rapid, being nearly one hundred feet to the mile. After moving up it for seven or eight miles we reach a beautiful little park, nestling cozily amid the mountains which surround it on every side; for by the time we reach this point the hills have grown into mountains. This park, which, at the suggestion of Professor Hayden, we named Box Elder Park, is nearly 1,000 feet above the level of Salt Lake; is somewhat circular in shape, its longest diameter about four miles and its shortest about three. It contains an area of some ten or twelve square miles, most of which can be irrigated from the streams that traverse it. It has three different levels, the upper terrace, which embraces the larger portion, being some 60 or 70 feet above the next, which lies along the west side, and along the border of which, some 80 or 90 feet lower, runs Box Elder Creek. Most of the water at present used for irrigating the upper and chief area comes from a very large spring in the southwest corner, and is carried round three sides. Here is the little village of Copenhagen, containing some forty or fifty families, mostly Danes. There are two saw-mills, which are furnished with logs chiefly from the mountains that lie to the southeast. Fir and pine are the only kinds of timber obtained, except an occasional aspen. The lofty hills to the south, which rest against a background of rugged mountains, are as smooth as a carpet, green throughout, varied only with light and dark shades, with here and there a tinge of brown, which fades insensibly into a beautiful green. Not a tree and scarcely a bush is to be seen upon them. To the southwest the sharper lines and crests of the ridges, as they extend down into the valley, show a little more of the mountain feature. They are also covered with the same green carpeting, with darker shades, and patches of shrubs and bushes scattered over the steep slopes. Still farther toward the west the hills grow higher and more rugged, with sharper outlines, while behind them a loftier range of rugged, snow-capped mountains shoots up, its peaks bristling with firs and pines. I mention these facts as showing a very striking feature of this region, to wit, the general absence of timber or arborescent vegetation of any kind on the smooth and rounded hills and ridges, while ruggedness, as a general thing, is accompanied with forest growth.

Passing up through a narrow, but not rough cañon, for a mile or two, we entered another little park of small dimensions, and apparently without any constant running stream to supply it with water for irrigating purposes. I saw quite a number of cattle grazing here, but there is no settlement.

Moving round to the northeast through a narrow, winding valley, over some smooth, rolling ridges, we entered another little basin about one mile and a half wide and three miles long, in the center of which is a large pond of clear water. Here we saw a flock of sheep, numbering about four thousand, which had been driven from some distance south in order to find pasturage, which here is good. The margins of this little sheet of water appeared to be the general meeting-point for all the snakes of this region. A few miles' travel through a narrow, tortuous defile brought us in sight of Cache Valley.

The short notice given of this important valley in my report of last year, although wholly from information received, was very nearly correct,

varying slightly in the dimensions only. It lies north and south, a portion being in Utah and a portion in Idaho, though the boundary between these two territories does not appear to be well known in this section. Its length, north and south, is about sixty miles, and its width from three to twelve, averaging about seven or eight. It is well watered on the east side by numerous creeks which rush down from the Wahsatch Mountains; the northwest portion is traversed by Bear River. Beginning at the south end and moving northward along the east side we arrive at these streams in the following order: Little Bear (or Muddy) River; eight miles farther, Blacksmith's Fork; one mile farther, Spring Creek; two and a half miles farther, Logan's Fork; eight miles farther, Summit Creek; seven miles farther, High Creek; eight miles farther, Cub Creek; then turning northwest, at a distance of ten miles we reach Bear River. Along the road, where it crosses these streams, there is generally a little village, the entire valley containing a population of some four or five thousand. Logan and Smithfield are the principal vilages.

A little south of Logan, Brigham Young, at the time of our visit, was having inclosed a considerable area of land for grazing purposes, where he is introducing some improved stock, chiefly Devonshire. Some of the village wards also have land here, which they are inclosing for stock-raising. Each town has one or more herds of cows, which are daily driven to the pasture by a herder, who has charge of them; for example, Logan has two herds, amounting to about 500; Providence, one of 275; Millville, one of 200; and Smithfield, one of 300. The area of land under cultivation is not large, not exceeding one-sixth of the area of the valley; but this is in part owing to the fact that stock-raising is the principal business, the valley affording, especially in the northern part, some excellent grazing fields. Wheat is the chief crop raised, the variety usually sown being what is called the Taos wheat; club-wheat is also used, but appears to require richer soil and more water than the Taos variety, hence it is not generally cultivated. I noticed some Indian corn growing, but the climate is rather too cold for it. No fruit-trees, so far as I could ascertain, have yet come into bearing, though a number of apple-trees, and some pear, plum, and peach trees have been planted. Gooseberries and currants appear to grow well and produce an abundance of fruit; the native currants, when transplanted and cultivated, make fine, large bushes, and bear abundant crops. Oats, barley, and the hardier vegetables can be grown without difficulty.

But a serious drawback to agricultural progress in this valley is the grasshopper scourge. At the time of our visit the lower half of the valley was literally swarming with the *Caloptenus spretus*, or "hateful grasshopper." Nor was this the only insect pest with which the farmers of this valley seem to be troubled; for throughout its entire length, the bushes and bunches of grass were often seen covered with "locusts," probably a variety of the *Cicada septemdecem*. I noticed these insects so abundant in some places that hundreds could have been gathered from a single bush or bunch of rye-grass. In the northern part we also encountered the large brown "cricket," *Anabrus simplex*, in immense numbers.

Bear River is situated in a deep narrow valley which it has cut through the northern part of the valley in a diagonal direction from northeast to southwest. As this stream affords an abundant supply of water, if a canal of some twelve or fifteen miles long was constructed to draw off its water, a large area of the northern portion of the valley, which is

without small streams, might be irrigated, and probably as much as 100,000 acres added to the cultivable area. Timber in abundance can be obtained in the mountains to the east, and good building-stone can be obtained near Logan.

In passing from this valley northward to Marsh Valley, we cross the divide between the Salt Lake Basin and the Snake River Basin, yet the dividing water-shed does not appear to interrupt the north and south direction of the ridges or valleys, and we only knew we were crossing the divide by noticing, after passing over a low, broad, transverse ridge, running from the mountains on the east to those on the west, that the direction of the water had changed. From this point to Carpenter's Stage Station, on Marsh Creek, (a tributary of Port Neuf River,) for most of the way we passed through narrow valleys, and over low, smooth, rounded ridges, generally covered with *artemisia*, and without water sufficient for irrigating even the small areas sufficiently level for cultivation.

Marsh Valley is but a small opening, being about one mile wide and four or five miles long. It is covered with a thick sward of rich nutritious grass, and will afford a good grazing field for a small herd. Some two or three families reside here, but more on account of the business resulting from the travel that passes here than for the purpose of farming or stock-raising.

From Marsh Valley to the Port Neuf, the country is rolling and broken, but not rugged, consisting of a succession of rounded hills and short ridges, which are smooth, without trees of any kind, and mostly covered with a scattering growth of stunted *artemisia*. Here and there the dark basaltic rocks show themselves above the surface.

The valley of the Port Neuf is a narrow winding cañon, the greater portion of its level surface consisting of a bed of columnar basalt. At one or two points there are small openings sufficient for one or two small farms; but with these exceptions, it is of no value in an agricultural point of view. This valley opens into the broad Snake River Plain.

As I shall reserve the discussion of the agricultural capacity of this broad plain for a future report, I will continue the notes of our immediate route, simply stating at the end my conclusion in regard to the eastern portion of it.

Leaving the banks of the Port Neuf we struck across the plains to Ross's Fork. The plains are broad and generally level, and very dry. Between these two points there is but one small stream; therefore, unless water can be brought from Snake River, which is some twelve or fourteen miles distant, there would seem to be no chance to irrigate it. The mountains to the right recede from our road as we move north, so that the streams would be compelled to flow a considerable distance over the dry plains. At this point the three prominent and somewhat noted *buttes*, which lie far to the northwest, come into view, and far beyond them the snowy crests of the Salmon River Range can be dimly seen.

The soil of this part of the plain is good, and only needs water to render it very productive and excellent farming land. Ross's Creek is a swift-running stream some 20 or 30 feet wide, and affords sufficient water to irrigate some three or four thousand acres of land. At the Indian agency which is established here some attempts in this direction have been made, which I believe have been attended with success.

As seen from the point where the road crosses this stream, the country to the north and west is mostly an open, level plain. To the east

are high, smooth, and rounded foot-hills, behind which arise loftier mountains, from which the snow had not disappeared at the time of our visit.

From here we moved northeast some fifteen or sixteen miles to Fort Hall, not the old Fort Hall of the maps, situated on the west bank of Snake River, but the new fort built east of the river, about thirty miles from the old locality. Traveling up the little stream for five or six miles we found it somewhat closely hemmed in by the hills, yet here and there affording small areas of level bottom-land covered with a luxuriant growth of grass. The rest of the distance, some eight or ten miles, was taken up in ascending and descending the lofty foot-hill we had to cross to reach the fort. Here we had one of the finest exhibitions I had seen of those smooth, peculiar hills which look so much like the folds in a lady's dress. This comparison may appear somewhat ludicrous; but while gazing from the summit of this ridge on the endless succession of the smooth, grassy ridges and hills piled and rolled together to form the large ridge, distance giving the grassy covering the appearance of velvet or silk, the colors of the folds varying as if by the difference in reflection of the light, the resemblance to the folds of rich cloth was more than simply fancy. Over an area of perhaps one hundred square miles I saw but three or four trees, standing as lonely remnants of the forests which once doubtless covered this entire area. It is evident that these hills and ridges were once rugged, and that by the action of water, snow, ice, &c., the rocks have gradually been worn down until the surface has been covered with the triturated *débris*, thus giving it the present smooth appearance. That these rugged spots which remain are covered with forests is evident to all who have traveled over the Rocky Mountain region; and I think we have sufficient evidence to show that these now smooth ridges, before their former ruggedness was worn down, were also covered with forests of pine and fir. Here I also observed that there was presented in a marked degree that peculiar arrangement of colors belonging to elevated regions; one side and the top of each of the descending ridges being pale-green or gray, while the other side or part of it was of a deep grassy-green. These variations tell us very plainly the direction of the prevailing winter winds; for the greener spots mark the place where the snow lay the longest, showing thereby that they are on the side opposite that from which the wind came.

Fort Hall is situated among the mountain foot-hills on a little stream that makes its way northwest to Snake River. A small area of ground may be irrigated around it, probably not more than five or six hundred acres. The officers in charge of the post are making some experiments in horticulture and agriculture, and though laboring under many disadvantages, the vegetables and cereals I saw growing there at the time of our visit indicate that wheat, oats, potatoes, cabbages, turnips, and pease can be produced without any serious difficulty on account of the severity of the climate.

The dryness of the air was found to be very great here, the difference between the wet and dry bulb reaching, in some cases, 34°, and standing generally each day during our stay at from 25° to 28°. During the middle portion of the day we found the rays of the sun hot and oppressive when there was no breeze blowing.

As a general thing timber is scarce throughout this entire region, that of value for lumber being found only on those mountains whose summits are covered with snow all or a great part of the summer. And here, as elsewhere in the whole Rocky Mountain belt, when the forest is once destroyed it is never restored. Most of the best lumber

used in the buildings at the fort, as I am informed by Captain Wilson, the polite officer in charge of the fort, was brought from Truckee, California, and most of the other sawed lumber from Corinne. About fifteen miles to the southeast some tolerably good pine and fir timber can be obtained in the mountains.

Leaving the fort we traveled northwest down the valley for a few miles, to where it opens into the Snake River Plain. This plain on the east side of the river is here somewhat interrupted by sand-dunes, which have been piled up by the wind, reminding one very much of those along the southern shore of Lake Michigan, a little east of Chicago. Some of these were of considerable size, some entirely bare, but as a general thing they were covered with a scanty growth of such plants as covered the surrounding plain.

Blackfoot Fork, which comes in here from the northeast, at the time we crossed it contained a considerable volume of water, sufficient to irrigate several thousand acres of the level plain through which it runs. At this point it is some ten or twelve yards in width, and averaged about three feet in depth, but on my return, a month later, the volume of water had decreased at least one-half. The hills to our right showed very distinctly the direction and force of the wind, which at certain seasons of the year must be quite severe. The mountains to the east recede, and appear to be lower than those farther south.

After crossing this stream we entered upon a broad, open plain, which is an almost uninterrupted level, covered with grass and sage-bushes. Eleven miles brought us to a small stream called Sandy Creek, which runs in from the northeast. On each side of it, for a short distance, are heavy accumulations of sand, which have been blown or washed into rounded ridges and gradually flattened. Yet these sandy points are mostly covered with ranker vegetation than the surrounding level. The hills to our right, while receding from our course, decreased in height, sending downward toward the west long, smooth slopes furrowed with shallow ravines, often so regular and straight as to remind one of the "lands" in the wheat-fields of Pennsylvania. But all around, as far as the eye could reach, were treeless mountains, hills, and plain, bare, without a grove beneath which a shelter might be found from the rays of the sun, nothing to remind us of arborescent vegetation except the little fringe of willows and cotton-woods that marked to our left the course of Snake River.

From Sandy Creek to Taylor's Bridge, at the crossing of Snake River, the broad, level bottom is composed of a rich sandy loam that needs but the addition of water to render it most excellent farming land. This bottom, on the east side, is some six or eight miles wide, and stands at a very moderate height above the ordinary water-level of the river. It is flanked on the east by a terrace some fifteen or twenty feet above the bottom.

At the time we crossed the river, going north, it was quite full, and rushed madly through and over the basaltic rocks that at this point line its channel. The average width is about one hundred and forty yards, and the average volume of water it sends down is probably 3 feet deep by 400 feet wide, running at the rate of 4 feet per second, making 4,800 cubic feet per second. At the time we first crossed it, (June 24,) the volume of water was more than double this, but on my return, nearly a month later, it did not exceed the estimate I have given. This amount of water will irrigate nearly a thousand square miles of land sufficiently for ordinary crops, such as the cereals. And as the general level is not far above the average water-level, the canals need not be of very great length, and therefore the water that returns to the channel can be used

again and again, thus increasing the area that may be rendered productive by it.

From this point we could see the sharp granite spires of the Three Tetons, some thirty or forty miles to the northeast, standing like grim sentinels, guarding the broad desert plain that surrounds their base. While encamped near the bridge, quite a rain-storm came up from the southeast. A few short, stunted cedars, of considerable size, grow along the banks of the stream wherever the basaltic rocks come to the surface.

Judging from the number of returning wagons we met from day to day, the freight from Corinne to Montana must be large, but much of this business will be cut off when the Northern Pacific Railroad is finished. Yet I think a railroad from Helena to Salt Lake Valley would ultimately pay; for if Snake River Valley was irrigated, as it might be, it would support a large population, and such a road would give Montana, and all this region, the advantage of both roads, thus bringing them in competition.

Having crossed the river, we moved up the west side over the margin of the broad plain, which here spreads out to the west thirty or forty miles, apparently as level as a floor. The soil is good, and the surface is pretty well covered with a mixed vegetation, but nothing larger than sage-bushes. As we moved northward, the mountains, which for a day or two had been dimly visible in front of us, began to loom up in formidable proportions, and, when we reached Market Lake, appeared to sweep around us in a semicircle, at a distance of forty or fifty miles. Some fifteen or twenty miles to the east we noticed two large *buttes* rising up abruptly from the plain, and having much the appearance of craters of extinct volcanoes, which they probably are, as this entire region seems to be underlaid with basalt. But on this point full information will doubtless be found in Professor Hayden's report, to which this is appended. The three *buttes* seen to our left at Ross's Fork were now distinctly visible to the southwest. The entire width of Snake River Plain, along this portion of it, measuring east and west, from mountain to mountain, is about eighty miles. The river evidently overflows a portion of the plain here when there is a flood, and the water which is left in the depressions forms the lakes, as they are called, but which are really but large ponds. Market Lake is said to have received its name from the following circumstance: Formerly, at a certain season of the year, buffalo, deer, antelope, and other species of game were accustomed to congregate here probably on account of saline matter deposited; and the hunters, when they found game scarce in other sections, would remark to each other, "Let us go to the market." There is now a stage-station here, around which I noticed a large herd of cattle grazing, while at some distance out on the plain a number of antelopes could be seen quietly feeding.

Soon after we had pitched our tents, the mosquitoes began to appear in vast swarms, and before sunset the numbers increased to such an extent that the air was almost black with them, but soon after nightfall all had disappeared.

Here we left the river and struck northward across the plains for the mountains. After traveling two or three miles we entered upon a broad, rough, slightly elevated ridge, composed of broken basalt, which has been elevated above the general level. This broad ridge, which does not have an elevation of more than forty or fifty feet, covers an area of about ten miles square, and, as there is no means of bringing water upon it, it must remain unfit for cultivation. It is covered throughout with a scattering growth of gnarled sage-bushes.

After leaving this we entered upon a dry desert tract, but sparsely covered with stunted *artemisia*. The sand in some places was very deep, and caused the wagons to drag heavily. This continued until we reached Kamas Creek, and even there the sand is often deep, and in some places cast up in long, low, rolling ridges. A few cotton-woods remain on the bank of this stream, but the bordering country has the most barren aspect of any that we have seen. From this point to the mountains, some twenty-five miles distant, which form the dividing line between Idaho and Montana, the character of the country was much the same as that just described.

As we come near the foot of the range, the land begins to rise gradually, and is much better grassed than that we had passed over during the two previous days, and the occasional little streams that flow down will afford a means of irrigating small areas. But I think the climate is quite severe, and that only the hardiest cereals and vegetables can be grown; but as there are no settlements here, no experiments in this direction have been made.

CHAPTER IV.

MONTANA TERRITORY.*

Montana, with the exception of Alaska, is the most recently organized Territory of the United States. Embracing that region lying between the forty-fifth and forty-ninth parallels of north latitude and one hundred and fourth and one hundred and sixteenth meridians of west longitude, it contains an area of 143,776 square miles or 92,016,640 acres, extending from east to west about five hundred and fifty miles, and from north to south about two hundred and eighty miles. It is separated into two very unequal areas by the dividing range of the Rocky Mountains, which forms the southwestern boundary from the west line of Wyoming to the intersection of 45° 40′ north latitude and the one hundred and fourteenth meridian. Here it suddenly bends eastward for some distance, and then runs north about twenty degrees west to the northern boundary of the Territory. About one-fifth of the entire area belongs to the Pacific slope, being drained by the head-waters of the Columbia, and four-fifths to the Atlantic slope, being drained by the Missouri and its tributaries. Extending from the mouth of the Yellowstone to the summit of the Bitter-Root Range, about two-fifths belong to the mountain region, three-fifths consisting of broad, open plains lying east of the Rocky Mountain Range. The mountain belt, which forms a broad margin along the western end, has probably an average width (direct measurement from the summit of the Bitter-Root Range to the east flank of the Rocky Mountains) of one hundred and seventy-five miles, running northwest parallel to the western boundary. Besides these two leading ranges and their interlocking spurs on the western slope, there are some minor ranges on the eastern side, which though comparatively small in extent are important in respect to the influence they have upon the course of the water-drainage and the form and direction of the principal valleys. In the northwest corner of Wyoming, near the point where the dividing range makes the western bend and passes out of this Territory, is what appears to be the great mountain nucleus of this

* The substance of this chapter has been furnished the Agricultural Department, and will appear in the Report of that Department for 1871.

region. Here the Big Horn, Yellowstone, Madison, Snake, and Green Rivers have their origin. From this mountain center a number of short ranges run northward, giving direction to a number of streams, and appearing like evidences of the abortive efforts of the elevating force to keep up its direct course. Along the southern border the Snow Mountains—the northern extension of the Big Horn Range—penetrate for a short distance into the Territory, compelling the Yellowstone to make a grand detour in order to sweep around the northern flank. In the central portion are the Belt, Judith, and Highwood Mountains, forming an irregular group of short and broken ranges, around which the Missouri sweeps to the northward before entering upon its long, eastward stretch. These also have a central nucleus situated in the western part of Meagher County, where the Musselshell, Judith, Deep, and Shields Rivers take their rise. North of the Missouri River the plain is interrupted only by Bear's Paw, the Little Rockies, and occasional Tetons.

As a general thing the mountains of this section are less rugged than in the Colorado group; although here and there are sharp, angular peaks, yet as a general rule, instead of the rocky, jagged sides and serrated crests, there are smooth slopes and rounded outlines. The elevation of both mountains and valleys, as will be seen from the list of elevations presented below, is much less than that of the great mountain belt of Colorado and Wyoming, and even that of New Mexico, Utah, and Nevada. But before presenting these statistics, I would call attention to the remarkable bend of the chief range at the southwest angle of the Territory. Traversing as it does three sides of a trapezium, it gives both to the eastern and western basin the form of a *cul de sac*, the one inclosing the head-waters of Clark's Fork of the Columbia, and the other the tributaries of the Jefferson. The former descends as we move to the northwest, while the latter descends toward the northeast. The dividing range, growing lower and lower from its entering angle, does not resume its usual altitude until it approaches the northern boundary of the Territory.

The following list of elevations, chiefly along a line running east and west near the middle of the Territory, will enable us to form a pretty good idea of the general elevation.

ELEVATIONS ABOVE THE LEVEL OF THE SEA.

	Feet.
Fort Union, at the mouth of the Yellowstone	2,022
Trading Post, on Milk River	2,388
Fort Benton	2,780
Forks of Sun River	4,114
Lewis and Clark's Pass	6,519
Blackfoot Fork, near the mouth of Salmon Trout Creek	3,966
Blackfoot Fork, near its junction with Hell Gate River	3,247
Missoula River, near the mouth of St. Regis de Borgia	2,897
Summit of Coeur de Alene Mountains, at Coeur de Alene Pass	5,089
Fort Owen, in Bitter-Root Valley	3,284
Deer Lodge City, in Deer Lodge Valley	4,768
Prickly Pear Valley, near Helena	4,000
Little Blackfoot, or Mullen's Pass	6,283

From this list we see that the western or intermontane basin reaches a depression less than 3,000 feet above the level of the sea; and that the least altitudes of the eastern slope range from 4,000 to 2,022 feet above the level of the sea. Comparing these with the altitudes of the

other Territories we find the difference much greater than would be anticipated. For this purpose I give here the elevations of a few points:

	Feet.
Albuquerque, New Mexico	5,032
Santa Fé, New Mexico	6,840
Denver, Colorado	5,300
Green River, at the railroad crossing	6,140
Salt Lake City	4,350
The Humboldt Sink	4,017
Fort Laramie	4,519
Sweet Water River, at Independence Rock	5,998
South Pass City	7,857
Fort Hull, (about)	4,200

From this we see that even the lowest point of the Great Basin, near the "Humboldt Sink," is 1,120 feet above the mouth of the St. Regis de Borgia and 733 feet above Fort Owen. This very important fact in regard to the physical geography of this Territory will serve as an explanation of its comparatively mild climate, notwithstanding its northern latitude.

The entire Territory may be divided into four sections, each having its water system and natural boundaries tolerably well defined, as follows: The northwestern, which includes all that portion lying between the Rocky Mountain and Bitter-Root Range; the southern, which is drained by the three forks of the Missouri; the southeastern, which is drained by the Yellowstone; and the northern, which includes the valleys of Milk and Missouri Rivers, and the bordering plains. Mr. Granville Stuart designates a fifth basin, embracing the country drained by the Boulders and the lower portion of the Jefferson; but for the present purpose, the foregoing division is probably the best, his fifth basin being considered as a portion of the southern section.

THE NORTHWESTERN SECTION.

This section, as before stated, is situated between the Rocky Mountain Range on the east and the Bitter-Root and Coeur d'Alene Mountains on the west, extending from the forty-sixth parallel of latitude to the British possessions, and including all of Missoula County and the southern half of Deer Lodge County. It is about one hundred and fifty miles wide and two hundred miles long, containing an area of thirty thousand square miles; and is traversed from southeast to northwest by Clark's Fork of the Columbia, and its leading tributaries.

The northern part is variable in character, having some open prairie country and valleys of limited extent, while much of it is broken and rugged and covered with heavy pine forests. It is drained by Flathead River, which has three leading tributaries—Maple River, coming from the northwest; Flathead, from the north; and another branch from the northeast. Near the forty-eighth parallel this stream expands into a beautiful lake about thirty miles long and ten or twelve miles wide. Below this it is of considerable size, flows in a southwest direction for about fifty miles, and joins the Missoula, the two forming Clark's Fork.*

* The main branch of this stream has a number of different names. From the junction of Deer Lodge and Little Blackfoot Rivers to the mouth of Big Blackfoot, it is called Hell Gate River; from there to the mouth of the Flathead it is called Missoula, from there it retains the original name of Clark's Fork, though it is sometimes called Columbia.

On the west side of the lake, near its southern limit, starts a range of broken and somewhat rugged hills, which extends northwest to the vicinity of Kootenay River, in the extreme northwest angle of the Territory. This range, which forms a divide between the waters of Maple River and those of Clark's Fork, is mostly covered with dense pine forests. The country, in the vicinity of Kootenay River, is composed chiefly of high rolling prairies, through which this stream, here some two or three hundred yards in width, flows with a moderate current. I am informed by Mr. Bonner, who I believe owns a ferry here, that the immediate valley of this river is from five to fifteen miles wide and well grassed, affording excellent pasturage. Potatoes have been grown there for several years, the tubers being large and quality good; and although the cereals have not been tried, he thinks the climate would present no serious obstacle to their production. The Kootenay Indians, for the last five or six years, have been raising potatoes for food, but until last season have obtained their seed from the whites, having too little foresight to lay up a supply for this purpose, until forced to do so by the refusal to furnish them any longer.

For twenty miles Tobacco Creek, a tributary of the Kootenay, runs through an open prairie country. It rises in the forest-clad range before mentioned and runs northwest. Maple River, for most of its course, to its junction with the Flathead, traverses a forest-covered section, its valley being narrow, until it enters the prairie. North of the lake there is a prairie some thirty miles in length, north and south, and fifteen to twenty miles wide, one arm of which extends northwest, in the direction of Maple River, and the other north.

On the east side of the lake the country is broken and mountainous, rising rapidly to the dividing range of the Rocky Mountains, which in this section presents some sharp and rugged peaks, its western side covered with heavy timber, while its eastern slope, which is less rugged, has only a growth of scrubby pine, which disappears toward the base. The region immediately around the northwestern angle of the lake is thickly wooded with pine, tamarack, and fir. The western shore is bordered by rocky hills covered with forests the greater part of its length; near the southern extremity these retire, leaving some open prairie country, which is well grassed over, and where some arable land may be found, but the extent is unknown. The eastern shore appears to be closely hemmed in by high and somewhat rugged hills, affording but little level land adapted to agricultural purposes. Below the lake Flathead River is from one hundred to one hundred and fifty yards in width, averaging 2 to 3 feet deep, and descending at the rate of 10 feet to the mile, at one point having a fall of 12 or 15 feet.

Hot-Spring Creek, which rises some distance west of the lake, flows southeast about twenty-five miles and enters the Flathead opposite Pend d'Oreille Mission. Along and in the vicinity of this stream there is some level and open country where good farming land can be found.

The valleys of Flathead and the little streams which enter it from the east afford some arable lands, but these are mostly in small detached areas, in one of which Pend d'Oreille Mission is situated. This central portion of the section under consideration is occupied by one of the reserves for the Flathead Indians. The following statement in regard to this mission by Colonel Wheeler, who visited it last season, may not be uninteresting:

"We were surprised at the extent of the farming operations carried on. All the grain and corn, potatoes and other vegetables, cattle and horses, butter and cheese needed for several hundred persons, are produced

here by the labor of Indians under the superintendence of the brothers. The mission, I believe, is entirely self-sustaining. We were told that wild grapes, plums, cherries, strawberries, and other small fruits grow in this valley in profusion and of excellent quality. This mission was established by Father De Smet, and I understand is the oldest in Montana. After an hour's rest and a bountiful dinner, we were invited to visit the sisters' school and department of the mission. The residence and school-house of the sisters and girls under their charge is made of hewn logs, is two stories high, about 60 feet long, contains six rooms above and six below, and has a wide hall running the whole length in both stories. It is exceedingly neat, airy, and comfortable.

"The most interesting part of our visit was the examination of the children in their studies. There are seventeen Indian and three white girls, varying in age from three to twelve years. They were all dressed alike in neat calico, faces clean, hair smooth, and eyes bright. Although somewhat bashful before strangers, they acquitted themselves very creditably in spelling, reading, writing, and arithmetic. The penmanship of some would do credit to any young lady. They seemed very fond of their instructors, and obeyed every request very cheerfully. While we were there an Indian and his wife, with his little girl, rode up to the mission. He said they had brought their child to the sisters' school, from near Colville, in Washington Territory, a distance of three hundred miles. The father and mother were assigned comfortable quarters, and bountifully fed, and their horses taken care of. The little girl was given in charge of the sisters, and an hour after appeared with the other girls, nicely washed and dressed as any of them, and apparently as happy."

I have given this interesting narrative not only as showing something in regard to the agricultural resources of that section, but also on account of the lesson it teaches in regard to obtaining influence over the Indians.

Jocko River runs through one of the prettiest valleys in this entire section. It is in the form of a triangle, its sides, which are nearly equal, being from ten to twelve miles long. It contains about fifty square miles, most of which can be easily irrigated, and which, if properly cultivated, will produce bountiful crops, the soil being quite fertile. Surrounded by lofty mountains, which form its triangular walls, little rills flow down into it from all sides, furnishing a never-failing supply of pure, clear water. Last year the Indian agent, with but little help except that of the squaws, (the Indian men being generally too lazy to work,) raised over 1,000 bushels of potatoes, 1,500 bushels of wheat, 300 bushels of corn, &c.; his corn, as he reports, yielding as much as 75 bushels to the acre.

This portion of the section has but few settlements in it, Jocko Valley being the principal one; north of the lake but little is known in regard to it, but upon many of the little streams which flow down from the mountains will be found small arable areas amply supplied with water for irrigation. And here, as well as on the western side of the section, many of these minor valleys are covered with forests of pine, fir, and other varieties of coniferous trees.

The southern district, which is somewhat quadrilateral, is surrounded on three sides by leading mountain ranges, the Rocky Mountain divide forming its southern and eastern boundary, and the Bitter-Root Mountain its west. It has three principal streams, which converge toward the northwest angle, where they unite to form the Missoula River, as follows: the Hell Gate, (the continuation of Deer Lodge,) rising in the southeast

angle, runs northwest diagonally through the district; the Bitter-Root, rising in the southwest angle, runs north near the western border; and the Big Blackfoot, rising in the Rocky Mountains, to the east, runs westward along the northern border. All that portion lying south of Hell Gate River is traversed north and south by a series of somewhat parallel ridges, separated by intervening valleys of greater or less width, each drained by one leading stream, which runs north to the great diagonal channel. The most important of these valleys, in an agricultural point of view, are those watered by the Deer Lodge and Bitter-Root Rivers.

Deer Lodge Valley is about forty miles long, with an average width of twelve miles that can be irrigated and cultivated. The surface is a broad, level bottom, occasionally flanked by terraces, which, at most points, can be reached by irrigating-ditches a few miles in length, as the descent of the stream is quite rapid. The soil is good, being covered in a natural state by a heavy growth of rich and nutritious grasses, and when properly irrigated and cultivated will yield abundant crops of such things as are adapted to the climate. Not only is it supplied with water by the central stream, which traverses the entire length of the valley, but there are quite a number of smaller rivulets which flow in from the mountains to the right and left. Below Deer Lodge City the hills close in upon the valley, leaving a narrow, fertile bottom, which does not average more than three-fourths of a mile in width.

As the elevation, which is but little under 5,000 feet, is greater than that of the valleys lying west of it, and most of those east of the range, its climate is less favorable for agriculture than some other portions of the Territory. Mr. Granville Stuart, of Deer Lodge City, who is a very careful observer, gives the following as the monthly means of the temperature for 1868 and 1869:

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1868	—1.5	25.	35.4	42.5	47.	59.2	61.	59.	50.	59.7	28.	26.7	41.
1869	20.4	24.6	24.	42.6	58.1	69.7	66.5	63.1	54.1	35.7	34.1	24.1	40.5

This gives the yearly mean of the temperature for two years 40.7, and the mean of the seasons as follows: spring, 41.6; summer, 69.7; autumn, 43.1; winter, 19.9. Although 1868 gives a higher mean than 1869, yet January of the former appears to have been unusually cold. This list also brings out the fact that the seasons are very variable, which is really the greatest climatic impediment to agriculture in these mountain regions. For example, there is a difference of 21.9 between the means of January for the two years; of 11.4 in March, that of 1868 being in excess, while in May, 1869, is 11.1 in excess, this holding good through the summer months; but in October that of 1869 falls 24° below that of 1868; whereas the means of the next month show 1868 6.1 below 1869. Such variations show that the mean annual depression of the thermometer is caused not so much by a uniformly rigorous climate, as by sudden cold spells, which, though continuing but a short time, serve to bring down the means. For example, we may feel confident from this table that some time during the month of October, 1869, there was a sudden change and a cold spell. It must be remembered that this record, which shows a somewhat rigorous climate, was made where the elevation is 4,768 feet above the level of the sea, and is con-

sequently below the mean temperature of the principal agricultural areas of the Territory; and, in addition to this, its peculiar position, as will be shown hereafter, probably renders it more exposed to winter storms than other portions of the section.

The record of the rain-fall has not been kept for a sufficient length of time to obtain a correct average for the different seasons; but the following may be of some interest, as giving an idea of the amount:

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1869	......	......	......	......	......	1.00	.25	.3	.1	.0	.6	.56
1870	.64	1.05	1.11	1.47	3.55	3.85	.28	.68	1.62	.66	1.17	.42
1871	.46	.88	1.30	1.32	2.29	1.07	......	......	......	......	......	......

This shows a total for 1870 of 16.50 inches, the snow of winter being reduced to the rain standard; and for the growing season, April to July, 9.15; or taking the average of these months, in 1870 and 1871, (July, 1869,) 7.04 inches, which corresponds very closely with the rain-fall in Salt Lake Basin for the same months.

Such cereals as wheat, oats, rye, and barley, and such vegetables as turnips, potatoes, cabbages, &c., can be raised here without any serious difficulty on account of climate. The valley is pretty well settled along its lower half. Deer Lodge City, one of the principal, and probably the prettiest, town of the Territory is here.

Little Blackfoot, coming down from the dividing range and having to wind its way through a mass of heavy hills, is hemmed in closely for most of its length, and affords but a narrow strip of arable land; but wherever a level space is found the soil is rich and productive, and covered with a green carpet of tall, rich grass. I noticed timothy growing wild along this stream, the citizens contending that it is from seed brought by Lewis and Clark. This valley, for part of its length, affords a roadway for travel and stage line from Helena, by way of Mullen's Pass, to Deer Lodge and points west. The bordering hills are generally well timbered.

Moving west from Deer Lodge River there is, as has already been stated, a succession of ridges and valleys running north and south parallel to each other. Of the latter, Flint Creek Valley is the first we reach. It is divided into two parts, an upper and a lower, by a gorge some four or five miles long. The upper portion is about ten miles long, with an average width of four or five miles, including that part of the bordering hills which can be irrigated. The lower part is about fifteen miles long, and, counting the valleys of both forks, has an average width of about five miles. The climate here is rather milder than that of Deer Lodge. The grazing is good. It is but sparsely settled.

Passing westward, across another ridge, we enter the narrow and rough valley of Stone Creek. This stream is of considerable length, and is about the size of Deer Lodge River, (60 to 75 feet wide,) very rapid and rough, flowing over bowlders and ledges. Very little farming land is to be found along its banks, but the stream will furnish excellent water power, and timber is abundant along the bordering hills.

The next and last valley toward the west is that of Bitter-Root River, which contains some of the finest agricultural lands in the Territory. From the mouth of the cañon, where the stream emerges from the mountains, it stretches directly north to Hell Gate River,

a distance of eighty miles. From Fort Owen, south, it varies in width from four or five to fifteen miles, averaging some nine or ten; north of this it is somewhat narrower, its average width not being more than five miles. It is all well adapted for agriculture, the soil being a rich, dark loam, mingled with sand and gravel; and where undisturbed by the farmer's implements is covered with luxuriant grass, supplying most excellent pasturage. In addition to the central stream, which is of considerable size, there are a number of small creeks and brooklets which flow into it mostly from the ridge to the east, of which the following may be mentioned in the order they come, beginning at the head of the valley: Weeping Child, Skarkahoe, Gird's, Willow, Burnt Fork, Three-Mile, Six-Mile, and Bogues Creeks, all entering from the east, and Nez Perces and Loulou Forks from the west. By proper efforts this entire valley can be irrigated and brought under cultivation, affording a rich agricultural area of at least four hundred thousand acres. As its elevation is much less than the valleys which have been mentioned as lying in the eastern part of the section, it has a much milder climate. But the difference in elevation will scarcely suffice as a sufficient explanation of the difference in climate between areas so near to each other; for here, especially from Fort Owen south, the valley will be free from snow and the weather comparatively mild, while other valleys, but a short distance north and of less altitude, are covered with snow, and the temperature several degrees colder. And this is not a mere accidental occurrence of one season, but so common as to have been noticed by all who reside in or have remained in the valley for any considerable length of time during the winter. This may possibly be accounted for in this way: the general course of the winds in this country, I believe, is from the northwest; Clark's Fork (counting from the head of Deer Lodge Creek to Lake Pend d'Oreille) forms a continuous channel up which they may sweep in order to make their exit from the section across the low gaps of the divide at the southeast corner. Bitter-Root Valley being narrowed below and shielded on the west by Bitter-Root Mountains, as a matter of course is much less liable to cold winds and storms. In consequence of the direction of the leading channel of this basin and the peculiar bends of the mountain-range here, reasoning *a priori* we would be led to the conclusion that the heaviest accumulations of snow would be found on the south side, in the Big Hole or Wisdom Biver Basin, which I understand is the case, though Mr. Stuart gives from the "Backbone" down to the mouth of the river on Big Hole as one of the areas of least snow during the winter of 1861–'62.

The following statistics, though meager, will furnish some data by which to judge of the climate of this valley:

Altitude of Stevensville, a few miles south of Fort Owen, 3,412 feet above the sea; of Fort Owen, 3,284; and of Missoula, near the junction of Bitter-Root and Hell-Gate Rivers, about 3,000 feet.

The mean temperature of the seasons and year at Fort Owen and Stevensville, from the imperfect observations taken at these points, is as follows:

	Spring.	Summer.	Autumn.	Winter.	Year.
	°	°	°	°	°
Fort Owen	48	69.6	45.6	24.9	47
Stevensville	47	69.6	45.5	27.6	47.4

But one of the best means of judging of the climate, so far as its bearing upon agriculture is concerned, is a list of its productions.

Not only can wheat, oats, barley, rye, and the hardier vegetables be raised, but Indian corn, of a tolerably good quality, is grown here year after year in sufficient quantity to supply the wants of the valley; melons, tobacco, and broom-corn thrive; and such fruits as apples, pears, plums, and cherries mature their fruit. Peach-trees have been planted, and during the past season gave promise of maturing their fruit, but whether success has attended this effort has not been ascertained; but it is quite probable that after a few years' trial and the trees become somewhat acclimated, they will succeed. Muskmelons, squashes, tomatoes, beets, carrots, and onions, of excellent quality and of large size, have also been raised. These facts give undoubted evidence of the comparative mildness of the climate in this northern latitude.

The following sketch by Major Wheeler, the United States marshal of the Territory, who passed through this and the adjacent valleys in the early part of the autumn of 1870, will convey a better idea of the beauty and agricultural resources of this part of the section than a more lengthened description. Speaking of the farm of Hon. W. E. Bass, he says:

"The large fields of wheat, corn, and potatoes, the vegetable-garden, and especially the flower-garden, excited our admiration. We saw fifty acres of wheat, averaging 40 bushels to the acre, and twenty acres of corn, averaging 50 bushels, ripe and sound. Everything else was in the same ratio. I brought away specimens of corn, onions, melons, tobacco, broom-corn, and even peanuts, which for quality and size cannot be surpassed anywhere. The flower-garden was a gem of its kind, covering half an acre, and containing over a hundred varieties. The barn is 165 feet long and 60 wide. The loft will hold 150 tons of hay, and the stalls below will accommodate the herd of dairy-cows, fifty of which are milked and the butter churned by water-power obtained from a small stream which irrigates the garden," (a very convenient contrivance, becoming quite common in this Territory.) "The house is prettily located among shady pine-trees, a forest of which extends back to the mountains. A saw-mill furnishes the lumber used on the place. On the opposite side of the valley, ten miles away, is the farm of Thomas Harris, esq. He has seventy acres of wheat, fifty of which are raised without irrigation, and the whole will average about 40 bushels to the acre; twenty acres being a voluntary crop. Mr. Harris has an orchard of apple and plum trees of four years' growth, and they look very thrifty, varying from 6 to 9 feet in height. Frost has never injured a twig. He has a field of timothy-grass, from which he cut twenty tons of excellent hay, or two tons to the acre. Here were vegetables of the best quality in the greatest profusion—watermelons, muskmelons, squashes, tomatoes, beets, carrots, and onions, of large growth."

Another gentleman, Mr. Bonner, who has resided in the country for several years, furnishes the following statement in regard to what he knows from personal observation of the productions of this valley, including the condition of the crops and orchards the present season; and in this he confines himself strictly to such things as will mature with ordinary care, not including those things which require extraordinary care and protection: wheat, oats, barley, rye, corn, (of such varieties as are usually raised in Western New York,) potatoes, (remarkably large and of a superior quality,) onions, turnips, pease, beans, tomatoes, melons, and cucumbers; also such fruits as apples, pears, plums, cherries, and the smaller kinds, these being now (August, 1871)

in fruit. A trial is being made with grapes and peaches, the latter, he understands, having some fruit on them, but the vines and most of the trees are yet too young to bear.

The banks of the streams are lined with cotton-wood and pine, the former reaching a height of 60 to 70 feet; and the latter much larger and of a superior quality, sometimes 150 feet high, 3 feet in diameter, and perfectly straight.

Although there is considerable timber between Deer Lodge and Bitter-Root Valleys, yet it may be considered an open country, furnishing a large number of extensive grazing-fields. And I may remark here that all of Montana from the east flank of the Belt Mountains to the Bitter-Root Range may be considered as one vast pasture.

The valley of Big Blackfoot is some forty or fifty miles long, varying considerably in width at different points, sometimes expanding into a broad, undulating prairie, through which the stream winds, flanked on one or both sides with a low bottom of moderate width; at others narrowing to what is called a cañon, though having a valley-surface of from a half to a mile or more in width. Above the cañon is a very pretty open area somewhat elliptical in shape, called the Belly, which is about seven or eight miles long and from four to six wide. The area lying between the lower part of Blackfoot Valley and Hell Gate is an open and rolling prairie, well covered with grass. Above the cañon the spurs and ridges are generally covered with pine forests. What portion of this valley can be irrigated I was unable to learn; but the descent of the stream being rapid, and it together with the tributaries from the north furnishing a large supply of water, not only the immediate bottoms, but also a large portion of the terraces and lower slopes, can be reached and rendered tillable.

The valley of the Hell Gate from the mouth of the Little Blackfoot to the lower end of the cañon above Missoula is some sixty-five or seventy miles long. For the first twenty-five or thirty miles it is bordered by an open, rolling country, sometimes broken into high hills, the immediate valley being narrow.

The cañon is about thirty-five miles long, having nearly all the way a narrow strip of good bottom-land from one-fourth to a mile wide. About thirty miles above Missoula the pine timber comes down into the valley, not a thick and massive growth, but in open groves of fine, tall trees, the soil throughout being good and yielding well under cultivation.

The Missoula Valley will average about fifteen miles wide down to Frenchtown, a distance of some twenty-eight or thirty miles. From there to the mouth of the Flathead River there are open pine forests, among which some farms have already been made. This portion of the valley varies in width from three to eight miles.

Although the altitude of this valley is less than that of the Bitter-Root, yet the climate is not so favorable to agriculture, being somewhat colder and more subject to frosts. This fact corresponds with the theory I have previously advanced, but possibly may be owing to other causes, as latitude, &c., but can hardly be owing to the proximity of higher mountains, as this is not the case. Thompson's Prairie, Horse Plains, and Kamas Prairie, which lie along Clark's Fork in the vicinity of and below the mouth of Flathead, contain considerable areas of good farming lands, well watered and having a moderate climate. Some settlements have already been made in Horse Plains.

The valley of Clark's Fork from Thompson's Prairie to Lake Pend d'Oreille is narrow and broken, having but few spots of arable land. It is well watered with little streams, which flow down from the hills to

the north, and is covered, for the most part, with forests of pine, fir, and tamarack.

It will be seen from the foregoing description of this northwestern section that it contains a considerable number of arable areas, and although, with the exception of Deer Lodge and Bitter-Root Valleys, these are of small size, yet in the aggregate they furnish quite an extensive agricultural surface. The detached form, surrounded by elevated ridges and mountain ranges, secures to each an ample supply of never-failing streams for irrigation. The extensive forests of the west side will also prove a source of wealth whenever a means of distributing the lumber is furnished by railroad communication with the less favored sections in this respect. The climate is also much less rigorous than would be anticipated in this northern latitude and mountainous region. I must acknowledge that I was agreeably disappointed in this respect.

Mr. Granville Stuart estimates the ratio of farming, grazing, and timbered lands in Deer Lodge County as follows: Farming, one-eighth; grazing, five-eighths; timbered, one-fourth. This estimate, with a slight change, will probably apply to the entire section, the proportion of timbered land being somewhat larger, and that of grazing lands smaller.

SOUTHERN SECTION.

This section includes that portion of the Territory drained by the three forks of the Missouri, viz, the Jefferson, Madison, and Gallatin Rivers, and the regions as far north as Helena. It is bounded on the south, west, and partly on the north, by the Rocky Mountain Range, on the east by the divide, which separates the waters of the Gallatin from those of the Yellowstone, and embraces Beaver Head, Jefferson, Madison, and part of Gallatin Counties. It is so irregular in form that it is difficult to estimate its area, but this probably amounts to fifteen thousand square miles.

The physical geography of this section, and especially the mountain regions surrounding it, is very enteresting, as here some of the great rivers of the West have their origin. Here the great Missouri, which traverses an area of sufficient size for an empire has its origin. In the mountain area, in the extreme northwestern corner of Wyoming Territory, which borders on this section, the Big Horn, Yellowstone, Madison, Green, and Snake Rivers all take their rise, the first three finding an outlet for their waters through the Mississippi to the Gulf of Mexico; the next through the Colorado to the Gulf of California; and the last through the Columbia to the Pacific Ocean, three thousand miles from the exit of the first. Here, amid a collection of the most wonderful scenery of the continent, is found the chief radiating point of the water systems of the Northwest, being equaled in this respect only by the mountain group of Colorado Territory. A minor radiating center is also found in the western part of Meagher County, where the Musselshell, Judith, Deep, and Shield's Rivers all take their rise within a small area.

Mr. Stuart divides what is here given as one section into two basins, the one drained by Jefferson River and its tributaries, the other being drained by the North and South Boulder Creeks and a few small tributaries of the Missouri below the junction of the three forks. The first basin embraces all of Beaver Head County and the western half of Madison, and is drained by three streams, the Big-Hole (or Wisdom) River, Beaver Head, and Stinking Water, which unite at the northeast angle to form the Jefferson. The first of these rising in the extreme western

part of the section, following the course of the great bend of the range, sweeps round in a semicircle, and, bursting through an intervening ridge, unites with the Beaver Head immediately south of Deer Lodge Pass. Its valley is crescent-shaped, and not far from eighty miles long, the widest part reaching fifteen or twenty miles. Big-Hole Prairie, which forms a part of this valley, is about fifty miles long by fifteen wide, well grassed, and affording one of the best summer grazing fields in the entire section. At some points the slope between the little streams descends by terraces. Although the soil of this valley is tolerably good, and water for irrigation abundant, the seasons are rather too cold to admit of its becoming an agricultural region, its average altitude being probably as much as 6,000 feet above the level of the sea, and the amount of snow which falls during the winter months considerable. The central part of the area inclosed by the circle of this river is occupied by Bald Mountain, from which the little streams, like radii, rush down to the encircling river, around the northern flank, while from the southern and eastern flanks others find their way to the Beaver Head. The latter stream, rising in the southwest corner of the county, flows north to its junction with the Big-Hole, the most important part of its valley being about thirty-five miles long, counting from its mouth upward, the width, which is tolerably uniform, averaging about six miles. Between these two rivers, for some twenty miles above their junction, is a level plain about fifteen miles wide, rather barren, but, if watered, which probably can be done, would make good farming land. Along the immediate bottoms the land is already mostly taken up and settled, but these do not average more than a half or three-fourths of a mile in width.

The principal tributaries from the west are Rattlesnake, Willard, and Horse Prairie Creeks; those from the east are Red Rock and Black-Tail Deer Creeks, the last three having valleys of considerable extent, which afford excellent pasturage and moderately good farming land. But the climate is rather too cold for anything except the hardier vegetables and cereals.

Stinking Water River (the Indian name of this stream is said to be Passamari) rises in the mountains at the south end of Madison County, and running north connects with the Jefferson a short distance below the junction of the Beaver Head and Big Hole. It has a valley some thirty-five or forty miles in length and of variable width, being separated into two parts by a short cañon immediately opposite Virginia City. The upper portion, which is some fifteen or twenty miles long and from one to five miles wide, is an excellent grazing section, which is already attracting the attention of stock-raisers. Some large herds of cattle, horses, and sheep have already been brought into this and Black-Tail Deer Valleys, where they pass the winter without protection and without other food than what they clip from the open pastures. Except so far as limited by climate, this part of the valley is well adapted to agriculture.

Below the cañon the valley is considerably wider than above, and affords a large area of good farming land, much of which is already occupied. The cereals and common vegetables are raised without difficulty, producing very good crops. By advancing upon the broad terrace which borders this valley on the east side below the mouth of Alder Creek, the breadth of tillable land can be largely increased, and the supply of water is probably sufficient to do this, the stream being some sixty or seventy feet wide, and averaging a foot in depth, running swiftly.

Where the three streams, Big Hole, Beaver Head, and Stinking Water, unite to form the Jefferson, there is a broad, level area, the greater part of which may be irrigated and make good farming land. And this point must become one of considerable importance as the Territory increases in population, on account of the advantages of its position; for here must always be the junction of the roads up Beaver Head and Stinking Water, down the Jefferson and over Deer Lodge Pass. No matter how much the general direction of traffic and travel may change, these must ever remain lines of travel so long as there is any passing north and south in this section. And although not possessed of so favorable climate as some other parts of the Territory, yet I think it will become, though limited in its extent, a very important agricultural area. Coming down from Deer Lodge Pass I was struck with the beauty of the valley, which looked like one vast meadow; and reaching the banks of the Big Hole and Beaver Head, which are here in close proximity, rushing down with heavy volumes of pure limpid water, I felt satisfied there would be no difficulty in forming a net-work of ditches filled with water over the entire area.

The valley of the Jefferson for twenty-eight or thirty miles below this point will average, exclusive of the table-lands which flank it, from three to five miles wide. The supply of water is ample, not only to irrigate the bottoms or valley proper, but also a large portion of the table-lands, which at some points expand to a width of eight or ten miles, but in other places form but mere strips. The stream, which is probably 120 to 150 feet wide and 2 feet deep, is fringed by a growth of cottonwood and willow, the former often of quite large size. The bordering mountains are clothed with a heavy growth of dark pines from their summits down to the sloping foot-hills; from this dark-green border the pale, smooth meadow sweeps down in a graceful curve on each side, giving to the valley a soft, attractive beauty seldom seen. As we rode rapidly along the margin of the stream we could imagine the delight of Lewis and Clark as they traversed the same valley, then doubtless teeming with game. More than sixty years have passed since they were here. What a change! A nation has sprung into existence on that which was then only the home of the red man, buffalo, and elk. And in all probability ere another half decade has closed the shrill whistle of the locomotive will be heard reverberating among these ridges and echoing along these valleys. Much of this valley yet remains unoccupied, probably because to irrigate the larger bodies of bottom-land would require the construction of somewhat lengthy ditches to draw off water from the river; the points which are settled being supplied, as a general thing, with water from the little tributaries that flow down from the mountain, as at Silver Star, &c.

Madison River, rising in the region of hot springs and geysers, near Yellowstone Lake, runs a northern direction to Gallatin City, where it unites its waters with those of the Jefferson and Gallatin to form the Missouri. It is worthy of remark that from the Beaver Head to the Yellowstone there appears to be a succession of short mountain ranges, or high ridges, running north and south, with intervening valleys of greater or less width, one of which is traversed by the Stinking Water, another by the Madison, and a third by the Gallatin.

The valley of the Madison is separated into two parts by a short cañon east of Virginia City. Above this it extends about twenty miles, varying in width from two to five miles, and is flanked by a succession of beautiful terraces almost perfectly horizontal, and which extend for miles along the valley, leading gently down from the mountains to the

river on each side. The soil is coarse gravel near the hills, but becomes finer as the immediate channel of the river is approached. On the east side of the valley several cañons give egress to wooded streams of considerable size, and afford the means apparently of almost unlimited irrigation.

Meadow Creek, which joins the Madison at the upper end of the cañon, traverses a comparatively small valley, containing some ten or twelve sections of level land. This valley well deserves its name, for it is covered with a dense carpet of fresh, tall, green grass, and is traversed by several sparkling brooklets, which, uniting, form Meadow Creek. All the terraces bordering this little valley are susceptible of irrigation and cultivation. There are now residing here some fourteen families, and others were expected before the close of the season.

That part of the valley of the Madison below the cañon is some twenty-five or thirty miles long, and varies in width from one to ten miles. From the cañon the river flows in a northerly course, its banks being only 6 or 8 feet high, yet not subject to overflow. The average width of the river is about 80 yards, the current swift, flowing over bowlders and gravel. The valley lies mostly on the east side, being somewhat narrow near the cañon, but expanding as it approaches its junction. The soil is good, and the valley well adapted to farming purposes, the greater part of the valley proper being already settled, and for the most part under cultivation. The high table-lands that rise from 200 to 300 feet above the level of the valley on the east side, and forming the bank of the river on the west, are unexcelled for grazing purposes, fine buffalo and bunch grasses growing in abundance. Unless the cañon should interpose an insuperable barrier, which, I think, is not probable, it will be possible, not only to irrigate the valley level, but also a great part of this plateau, the supply of water being sufficient to water a large breadth. It is very probable that ere long a good wagon-road will be made up this stream and its tributary, Fire-Hole, from the vicinity of Virginia City to the geysers, hot springs, and other wonderful scenery around Yellowstone Lake.

The Gallatin River is formed by two streams, called East and West Forks. The East Fork flows for some distance through a cañon, which ceases about twenty miles above its junction with the West Fork. From this point it flows in a northwesterly direction, being 50 or 60 yards wide, but shallow, its banks high and not subject to inundation. The bottom-lands on the east and west sides taken together have an average width of about three miles, a large portion of which is under cultivation. On the east side the bench-land is about 20 feet above the bottom, and is well grassed over. This extends eastward for seven or eight miles to Mill Creek, or the right fork of the Gallatin. This might be irrigated with moderate expense and trouble, and made as productive as the bottoms which it flanks, so noted in the Territory on account of the heavy crops they yield. Mill Creek runs northwest through Bozeman, where it connects with East Fork.

Timber is scarce in these valleys, nothing but cotton-wood being found on West Fork, and that in small groves, except near its junction with East Fork, where there is a considerable quantity of large cotton-wood. The greater part of the timber used in this valley is hauled from the mountains south. There is a large amount of stock raised here, the grazing being good. A flouring-mill has been erected on Mill Creek, near Bozeman, and another will probably soon be built.

East Fork, coming from the Grosfoot Hills, northeast of Bozeman, flows in a westerly course for six or eight miles, thence northwest to its

junction with West Fork. It is some forty or fifty yards wide, flowing swiftly, its banks being high and not subject to overflow. The immediate valley is from two to five miles wide, while on the south a low table-land, not more than fifteen or twenty feet above the bottoms, stretches out to the south, ascending with a gentle slope to the foot of the mountains. The supply of water is ample, and the facilities for irrigation excellent. This is one of the finest valleys of this section, the soil being good and the climate favorable, on which account it has attracted settlers, so that at this time it is mostly inclosed and under cultivation; and it is probable that ere long an encroachment will be made on the bordering plateau. The stream is fringed by a fine growth of cotton-wood and aspen, except which there is no other timber in the valley, this being supplied from the mountains to the northwest.

As a general thing, the southern part of this section is not so well timbered as the regions to the northwest, but the mountains will furnish a supply for ordinary purposes, yet even these in many places present quite naked slopes, being smooth and grassed over to the summit. The evidences of the gradual wearing down of the mountains and filling up of valleys are very marked in this part of the Territory, and wherever this is the case but few forests are to be found. In fact, it may be laid down as a rule that has but few exceptions here, that wherever the mountain sides are smooth there are no forests. In some places the levels of broad valleys, when seen from a distance, look like streams flowing down with a somewhat rapid current; and glancing up to the mountains from which they descend, we see the immense fissures and excavations from which the *débris* has worn away. Often across these river-like ribbon plains, we see where another ancient stream has swept across it to the channel the modern stream has cut on one side near the base of the parallel mountain. At other places little, smooth, sloping deltas will be seen at the base of the mountain, where the *débris* cut from the deep excavation above has been deposited. But over such areas there is no forest growth, nay, not even a solitary pine or a stunted cedar, the omnipresent *artemisia* being the only ligneous plant, if it can be called such.

Passing northward from the central part of the Jefferson, we enter what Mr. Stuart calls the Eastern Central Basin, and which he describes as follows: "This is drained by the Missouri River below the Three Forks, and above them by [the lower tributaries of] the Jefferson, the North Boulder, South Boulder, and Willow Creeks. It is also traversed by the lower portion of the Madison and Gallatin Rivers, which form a junction with the Jefferson in a fertile plain of considerable extent. It contains a large amount of arable land, with a climate comparable with that of Utah, and is about one hundred and fifty miles long, north and south, by eighty, east and west. Its five principal valleys are the following: The valley of the Three Forks; of North Boulder; of the lower part of the Jefferson; of the Madison, and of the Gallatin, furnishing a larger amount of farming land than the basin of the Beaver Head and tributaries." It will be seen that I have included a part of this basin in the descriptions of the valleys already noticed. Mr. Stuart evidently includes the parts below the cañons mentioned, in this basin.

The valley of the Missouri along this part of its course is narrow, but quite fertile, possessing a very favorable climate. It is watered on the east side by numerous small streams, which flow down from the Belt Mountains. The interior of the basin is traversed by several sharp and elevated ridges; the principal one, stretching from near the lower part of the Jefferson a little west of north, connects with the Rocky Mountain

Range, near the origin of Prickly Pear Creek. The North Boulder runs along the western base of the ridge, through a valley of moderate width, while west of it runs another ridge separating its waters from those of White-Tail Deer Creek. These ridges are clothed with pine timber of an excellent quality. And along some of the slopes the rank vegetation indicates a greater degree of moisture than is usual in this region, especially on the divide which separates the Boulder from Prickly Pear Valley. I noticed here the marks of a recent heavy rain, which had caused sudden torrents to rush down the indentations of the ridge which flanked the valley, tearing up the grass and pebbles and bearing them down to the base. Branching off from the first-mentioned ridge, near the center of Jefferson County, starts another ridge, which, running north, forms a divide between the Prickly Pear and the Missouri.

Prickly Pear, and Ten-Mile Creek, its principal tributary, have very pretty valleys, which, though irregular and contracted at some points by the approaching ridges, at others expand into broad, open prairies, having surfaces as smooth as a meadow. One of these beautiful, meadow-like openings is in the vicinity of Helena, across which one may look from the city and see the noted landmark repeatedly mentioned from the days of Lewis and Clarke down to the present time—the Bear's Teeth. This valley is from five to fifteen miles wide, and some twenty or twenty-five miles long. Although rich and productive, unfortunately the stream which traverses it only furnishes water sufficient to irrigate a part of it. A proposition has been made to bring water from Jefferson River, which is said to be practicable; but whether this will be carried out or not I am unable to say. The proximity to the chief city of the Territory would certainly render the land valuable, and such a canal would be useful not only for irrigation but also in connection with the mining operations.

Major J. F. Forbes, who has been farming in this valley since 1865, and has made the raising of vegetables for the city somewhat a specialty, furnishes the following information in regard to its productions: "Wheat, after the first few crops (which are generally heavy) have been cut, yields from 20 to 40 bushels to the acre, though as high as 82 bushels have been taken from one acre; and entire crops have averaged 52 bushels on fresh soil. One difficulty experienced is, that volunteer crops mix with those that follow; this does no damage when feed-crops, as oats and barley, are raised; but when wheat follows other crops the mixture injures its value. And it may be set down as a rule, with but few exceptions, that volunteer crops are, in the long run, an injury to any section. If these do no other injury they beget a thriftless system of farming, under which the soil is deteriorated, and the yield becomes less and less and the quality inferior."

Major Forbes says that the weight is usually about 60 pounds to the measured bushel. The average yield of oats is about 40 bushels to the acre; barley, 30; but the yield of the latter crop often is as great as that of oats. The following vegetables grow well, no difficulty from the climate being experienced in raising them: Potatoes, turnips, ruta-bagas, beets, cabbage, carrots, onions, parsnips, pease, beans, and radishes. Tomatoes can be grown with care, but are liable to be injured by the frost before maturing. Spring-wheat is generally sown in March, and sometimes even as early as the last of February, which is certainly very early for this latitude; but even as late as May will answer. Harvest usually commences in the latter part of July. When winter-wheat is sown, it is usually put in in September and October; but it generally comes out too soon in the spring, and is liable to be bitten by the frost after

jointing. Currants, gooseberries, strawberries, and raspberries do very well, their fruit growing and maturing without any difficulty from the climate; in fact, the soil and climate seem peculiarly adapted to the growth of the first two. The native varieties of gooseberries and currants bear transplanting without injury, improving under cultivation. Native raspberries and strawberries have not been tried; it may be that the former will bear transplanting, though, as shown in my previous report, the experiment failed in Colorado. Other fruits, so far as tried in this valley, have proved a failure; but Major Forbes thinks that some varieties of the apple might succeed. He says that an experiment made with hemp shows that it grows remarkably well. He planted some seed in a yard in Helena, which is some 400 or 500 feet above the valley-level, and some of the stalks grew to a height of 10 or 12 feet, and as large round at the base as a man's wrist. He is now testing it on his farm, and at the time I met with him (July 12 to 15) it was growing finely. He has raised hemp in Missouri, and is satisfied, from his experience with it in that State, that it can be produced here as easily and of as good quality as there. The climate, he states, is variable; often the weather is mild and open at Christmas, but with previous killing frosts; but at other times winter commences much earlier. Snow does not generally set in until in December, and does not often fall in the valleys after March; it never falls to any great depth, seldom enough for good sleighing. This fact in regard to the fall of snow appears somewhat paradoxical to those who have never visited those mountain regions. They read and hear statements in regard to snow in the mountain 15 and 20 feet deep, and then in the next breath are told that cattle can graze out all winter, the snow not being sufficient to prevent this. It must be acknowledged these statements do appear to be somewhat contradictory, yet both are true; an explanation of which will be found in my former report.

In order to afford as much data as possible in regard to the valley under consideration, it should be stated that barometric measurements, taken in Major Forbes's door-yard, show the elevation to be just 4,000 feet above the level of the sea.

On the east side of the Missouri, in the bend which this river makes here, from a north to a northeast course, are two or three valleys, which may be considered, in this connection, though not strictly, belonging to the southern section. North Deep Creek, which rises in Belt Mountains and flows north to the Missouri, has a valley some forty or fifty miles in length, which averages about three in width. At one place, for a distance of fifteen or twenty miles, it widens out to an average of five miles, but at other points the spurs of the mountains close in upon it, rendering it quite narrow. South Deep Creek gives a valley of twenty-five or thirty miles in length and four or five in width, at no point within this distance being less than two miles wide. Water sufficient to irrigate these valleys can be obtained from these creeks and their tributaries, and near the mouth of the latter any deficiency can be supplied from the Missouri. The soil is good, and considerable settlements have already been made here.

NORTHERN SECTION.

This section comprises all that part of the Territory lying east of the Rocky Mountains and north of the divide which separates the waters of the Missouri from those of the Yellowstone. It is an extensive region, stretching from east to west some three hundred and fifty or four hundred miles, and varying in width, north and south, from one hundred

to one hundred and seventy-five miles, including the north part of Deer Lodge, all of Choteau, and most of Meagher and Dawson Counties. With the exception of the portions occupied by Belt, Highwood, and Judith Mountains south of the Missouri, and by Bear's Paw and Little Rocky Mountains north, it is generally an open, treeless plain, gradually descending eastward, with an average slope of 5 feet to the mile. But this descent differs very materially in the portions east and west of Fort Benton, that part west to the foot of the mountains having an average descent of from 12 to 15 feet to the mile, while that east has an average of less than 3 feet, if the barometric measurements taken along this line are to be relied upon. If this rate of descent east of Fort Benton is correct, it lessens, to a considerable degree, the prospect of redeeming any great portion of the plains, for it renders it impossible to reach the higher table-lands with water from the Missouri.

Along the east base of the Rocky Mountains, from the British possessions south to Sun River, there is a strip of arable land, about thirty miles in width, which is well watered by numerous little tributaries of Marias, Teton, and Sun Rivers. The descent here being somewhat rapid and these streams but a few miles apart, flowing in rather parallel lines, a large portion of this strip, which is about one hundred miles in length, can be irrigated and brought under cultivation. As it is yet wholly unoccupied, except by roving Indian bands, consequently no experiments in farming have been made, by which we may judge of its climate; but Mr. Hard, who has been traveling over this part of the Territory, summer and winter, for some years, states that the seasons are not severe, and that he is satisfied, from his knowledge of the climate, that the hardier cereals and vegetables can be raised without difficulty from climatic influences. The grass is very good, and the great buffalo herd of Eastern Montana, apparently fleeing before the Sioux, has, during the present year, been moving over into this region. The Marias River, after it enters upon the plains, runs through a deep channel, bordered, in part, by broad table-lands, and partly by long, sloping hills, a part of which, by the construction of long ditches, may be reached and irrigated and rendered suitable for agricultural purposes.

Teton River is probably over one hundred miles long; its two branches, rising in the Rocky Mountains west of the Teton, flow round this *butte* and unite at its east base. It has some good bottom-lands in its valley, which varies from two to six miles in width for a part of its length, but at other points is quite narrow. The bordering plains are generally undulating, but a part is composed of level table-lands, which are from 50 to 75 feet above the valley-level. The stream is rather small, its average width being about twenty-five or thirty yards, but it is a constant runner; its lower portion runs slowly, the descent being very slight.

Sun River, rising in the Rocky Mountains immediately west of Fort Shaw, runs east about seventy-five miles, passing by this fort, and empties into the Missouri. It forms the north boundary line of Lewis and Clarke County. The immediate and cultivable valley of this river varies in width from one to three miles, the soil being of the very best quality. There are terraces, at some points, flanking the bottoms, which are of moderate height, and may be reached by irrigating ditches, increasing the breadth of farming lands in this beautiful valley, which is considered one of the finest in the eastern part of the Territory. The stream is about sixty yards wide, flowing rather swiftly over a gravel bed, seldom, if ever, overflowing its banks. There are, as yet, but few

settlements in it. Fort Shaw, situated about six miles east of the Helena Guide Mountains, is the highest settlement in the valley. Lower down, about four miles, is the Sun River crossing, on the main road from Helena to Fort Benton, around which there are several farms under cultivation. From this point to its junction with the Missouri, a distance of some twenty-five miles, the valley increases in width from three to five miles. There is some cotton-wood and aspen along the banks of the stream, but other timber is scarce, and will have to be hauled from the mountains. The higher table-lands, on the north and south, offer most excellent grazing fields, the soil being generally very fertile, that of the plateau on the north needing but irrigation to make it as productive as the bottoms of the valley.

The following statistics, from the records kept at Fort Shaw, will furnish some data in regard to the climate of this part of the Territory:

Monthly means of the temperature for two years.

January	21.28	August	67.15
February	30.39	September	54.04
March	36.58	October	49.12
April	46.51	November	39.92
May	56.04	December	26.75
June	64.98	Year	47.33
July	70.22		

Average monthly and yearly amount of rain and melted snow for two years.

	Inches.		Inches.
January	.11	August	.27
February	.24	September	.95
March	.44	October	.75
April	.54	November	.39
May	1.53	December	.33
June	2.63	Year	8.951
July	.78		

This shows a very moderate climate for this northern latitude, comparing, as has been asserted by Mr. Granville Stuart, very favorably with that of Utah; the mean temperature of the seasons being as follows: Spring, 46.38; summer, 67.45; autumn, 47.69; winter, 29.47.

The amount of rain-fall during the growing season, from March to July inclusive, is 5.92 inches, less than one-third of what is necessary to supply ordinary crops. The monthly means of the winds for the range of two years was, without exception, from the west.

The valley of the Missouri from the Three Forks to the mouth of Sun River is very rich and fertile, but rather narrow, varying from three to eight miles in width; but at some points the hills close in upon it, leaving but a narrow strip of bottom-land along the stream. The length of the valley between these points is about one hundred and fifty miles. It is tolerably well settled, the climate being mild and the productions as varied as any portion of the Territory. Wheat, oats, rye, barley, corn, and the usual vegetables grow well and produce heavy crops, Helena receiving a large part of its supply of vegetables from this valley. Such fruits as apples, plums, cherries, currants, raspberries, and gooseberries may be grown and matured here, the climate presenting no serious obstacle.

As a general thing, after leaving the rapid descent near the base of the mountains, and entering upon the broad, open plains, the rivers of this section run in deep channels, which like great ditches traverse the plains, and are often for long stretches sunk from 100 to 150 feet below the surface.

On the south side of the Missouri the most important basins within this section are those of the Judith and Musselshell Rivers. The Judith Basin is a broad depression, spreading out for forty or fifty miles, and extending north and south about eighty miles. It is traversed its entire length by the Judith River, which has three principal tributaries—West Fork, South Fork, and Big Spring Creek. West Fork is a short creek, affording a moderate valley, but in regard to which I received no satisfactory information. The valley of South Fork is very irregular, frequently closing up. It is about twenty-five miles long, the ten miles next its mouth averaging two miles wide; is generally quite narrow, here and there affording an open bottom sufficient for a few farms. The lands which flank this valley are more rolling and irregular than usual in this basin, yet they are covered with good grass. Big Spring Creek has one leading tributary, Cottonwood Creek, which has a valley twelve miles long and from half a mile to two miles wide. The valley of Big Spring Creek is fifteen or twenty miles long and quite narrow, varying from half to one mile in width. The supply of water in all these valleys is sufficient to irrigate all the lands in the madapted to farming purposes. The area between the two last valleys consists of a level plateau about one hundred feet above the streams, and during the summer season has a bright-yellow hue from the vast number of *Helianthi* which grow here.

The Judith Valley proper is about eighty miles long, and varies in width from one to four miles. The bordering regions, as we approach the Missouri, grow barren and assume that appearance to which the name *mauvaises terres*, or "bad lands," has been applied; yet the surface is generally covered with a moderate growth of bunch-grass. Stunted pines and cedars grow along the Missouri from Fort Benton to the mouth of the Musselshell, for twenty or twenty-five miles back on the south side.

From the mouth of the cañon on Musselshell below Fort Howie, for twenty-five miles down, is a very fine farming country, the valley averaging five miles in width, the soil good, and the climate favorable. Near the mouth of this stream the valley is narrow, being cut deep into the plains, the bottoms not averaging more than a mile or a mile and a half wide; nor is the soil so good as along the upper portion. I could gain no information in regard to the intermediate part of this valley, but the bordering plains for a part of the distance, at least, probably consist of "bad lands," similar to those near the mouth of Judith River, and along portions of the Yellowstone.

SOUTHEASTERN SECTION.

This section includes the area within the Territory drained by the Yellowstone and its tributaries. Little is known in regard to its agricultural resources. The following account, obtained from Judge Hosmer, of a voyage down this stream in a boat, contains, perhaps, all that has been ascertained in regard to it up to the present time. It was first published in the Herald, Helena:

"The description of the lower valley of the Yellowstone given by Captain Lewis, without being full, is very accurate in geographical information. I was able by it to anticipate our approach to the various landmarks, rapids, and the mouths of the various tributaries. In minor details it is deficient. No continuous account of this valley from the cañon, twenty-five miles beyond Bozeman, to the mouth, a distance (by the stream) of eight hundred and twenty miles, has ever

been published. For the first eighty miles, from the mouth of the cañon, the river is almost one continuous rapid, and numerous ledgy islands are scattered along, which furnish coverts for large flocks of ducks. The banks are generally abrupt, in many places precipitous, thickly covered with stunted pines. Occasional accumulations of *débris* spread out into small bottoms, covered with immense cotton-woods. The banks on each side rise gradually into lofty hills, but the vegetation is light. Long, high ranges of mountains approach the river on each side. The water here is pure and very transparent. The bends of the stream are long and straight reaches, where the eye can often follow it for six or eight miles. Dense thickets of willow grow along the margin and on the islands. The second day we came in sight of the vast ridge of yellow sandstone, from which the river derives its name. This ridge appears to be about 300 feet high, and this part twenty miles long; the bluff it forms being precipitous and the top covered with pines. The valley of the river here is greatly expanded, spreading out into alluvial bottoms six or eight miles wide, gradually rising into upland and foot-hills. The soil here is equal to that of the Gallatin; but the descent of the river is much less rapid than above, miles intervening without any perceptible inclination. The termination of this portion of the ridge is at an angle of the river, where it has worn a passage through the rock on each hand, exhibiting a sheer, bold precipice of stratified sandstone, very hard and of deep ocher color. The river is quite shallow where it crosses this ledge, which stretches off on the southwest side in a straight line across the valley for twenty or thirty miles. The bottoms here are extensive (between the ridge and river) and are susceptible of high cultivation. There are frequently long groves of cotton-wood. We passed through this marvelous ridge five or six times in traveling three hundred miles. In some places it follows the river for miles, casting its somber shadow on the water. In others, it is curiously eroded into resemblances of towers, castles, citadels, &c. At the terminus of the ridge the river, increased to twice the size it has at the commencement, by the contributions of the Rose Bud, Clarke's Fork, and Big Horn, is fully one mile wide and very deep. Its waters turbid, its banks low, it rolls an immense volume of water down undisturbed by a ripple, through large, spreading meadows beautified by occasional trees and carpeted with a thick growth of grass. With the exception of a few rapids, some of which are formidable, this is the general character of the scenery until we approach the mouth of Powder River. Here a sudden change takes place, and all at once we are ushered from the highest state of verdure to that of extreme, absolute desolation. Here commence the *mauvaises terres*, and from this point to its mouth the same general features characterize the scenery as those found along the Upper Missouri, intensified, if possible, by frequent views of long burnt plains, seamed with immense ravines and dotted with enormous tables of baked clay. It is without exception the most horrible-looking country I ever saw. The hills and mounds of stratified clay along the bank of the river rise 1,500 feet, void of vegetation. The river is here a dark drab color, with shifting channels and numerous sand-bars. Its clay-banks for hundreds of miles exhibit on each side continuous veins of decomposed lignite. A railroad could easily be built along its course, except the one hundred and eighty miles from the mouth of Powder River downward. Above Powder River the obstructions are few and easily overcome. Three or four hundred miles would be through the largest and richest valley in Montana, yet unsettled, and not more than 1,500 or 2,000 feet above the level of the sea."

STOCK-RAISING, ETC.

Without injustice to any other part of the West, it may truly be said of Montana that it is the best grazing section of the Rocky Mountain region. Not only are the open plains and prairies covered with rich and nutritious grasses, but also the smooth hills and naked mountain slopes, and the same rich carpet continues even beyond these far up into the timber. Wherever a fire has swept up the mountain side, destroying the pine-trees, leaving the blackened stems and stumps to mark the place where the forest stood, there springs up, in a marvelously short space of time, a tall, green grass covering every possible spot where it can gain a foothold. Here, as in other parts of the western country, as is well known, the grass cures on the ground instead of rotting, remaining in this state all winter, furnishing, in fact, a better food than if cut and cured. There is seldom any difficulty experienced on account of the cold or snows of winter; many who have stock running on the prairies making no preparation for winter-feeding, which is seldom necessary. Even in the upper part of Stinking Water Valley, where the climate is considered somewhat rigorous, not only the regular herds are wintered on the open pastures, but also cows pass this season with no other food than that they clip from the grazing-field, and, although regularly milked, come out in the spring in excellent condition. At one place I saw cows which had thus passed the winter on the range, giving milk the entire season, yet they were in such a fine condition that they would have made excellent beef; some of them gave as much as three gallons of milk morning and evening, as I can testify from personal observation. Notwithstanding this fact, cows command a very high price, the best bringing readily from eighty to one hundred dollars; this, no doubt, being due to the demand for stock cattle. Stock is rapidly coming into the Territory, which must before very long bring down this price. Cows begin to bear very young when running with the herd, it being no uncommon thing for them to have calves at fifteen and sixteen months; in fact, a few instances have occurred where they have borne young before ceasing to follow the mother.

I have received but few statistics in regard to the herds in this Territory. That of Messrs. Poindexter and Orr, on Black-Tail Deer Creek, at the commencement of the present season was stated to be as follows: 2,467 sheep; 1,500 lambs; 1,500 cattle; 750 calves; 450 horses; and 75 mules.

CHAPTER V.

LETTER OF PROFESSOR G. N. ALLEN.

[The following very interesting letter from Professor G. N. Allen, in regard to certain methods of irrigation in Santa Clara Valley, California, contains so many interesting statements in such a small compass, although appertaining to a section outside my field of observation, that I have thought best to give it in the clear and explicit language of the writer.

C. THOMAS.]

Professor CYRUS THOMAS:

MY DEAR SIR: As promised when we parted, I give you herewith

the results of my observations and inquiries in the San José Valley, or Santa Clara district, California.

This valley is beautifully situated between the main Coast Range and one of its spurs, the Santa Cruz Mountains, and extends directly south from San Francisco Bay. It is about seventy miles in length by twenty in breadth, and presents a nearly level surface throughout. It boasts an intelligent and industrious population, and is certainly as highly cultivated as any other of the many lovely valleys of California. Near its center are located the handsome and enterprising cities of San José and Santa Clara. The water in this valley used for domestic purposes, and to some extent for irrigation, is derived chiefly from surface-wells or wells excavated in the superficial deposits, and is lifted by the inevitable and not unpicturesque "California wind-mill," though there are besides many artesian or free-flowing wells, which penetrate to and derive their supplies from a stratum lying at a much greater depth.

Being desirous of obtaining my information from the most trustworthy sources, I called early on a Mr. Gould, to whom I had been recommended, and who cultivates a large fruit plantation near Santa Clara. This gentleman, whom I found to be as intelligent as he was enterprising, very politely showed me over his extensive grounds, and freely answered my inquiries. Besides large vineyards and orchards, Mr. Gould has about forty acres of the small fruits, strawberries, blackberries, &c. These small fruits only are systematically watered by artificial means. To accomplish this he has three artesian wells of seven-inch bore and about 300 feet depth. Until recently all his wells have been free-flowing fountains, but in consequence of the greater number of wells now existing, and in part doubtless on account of the smaller amount of water that has fallen as rain within the last two years, one of his wells at least has ceased to flow, and it has become necessary to raise the water by mechanical appliances. Horse-power was applied last year, but this year he has built a steam-engine. The engine is of twenty horse-power and cost $2,000. Working at about half its capacity for fifteen hours per day, and at a cost in fuel and labor for the same time of four and a half dollars, he raises sufficient water, with a little aid from his free-flowing wells, to supply abundantly his small fruit-grounds. Application is made daily to certain portions only, but so that the whole forty acres shall be watered about once a week during the season of fruitage. His vines are planted seven feet apart. As to beets on alkaline soils his experience is that they attain a large size, but have a rank growth and coarse-grained texture. With regard to the amount of saccharine matter in such beets, he had no data. Mr. Gould employs and prefers Chinamen as laborers.

On the mountains, between Santa Cruz and Santa Clara, 2,000 feet, perhaps, above the valley of San José, grapes and other fruits do excellently well. The grapes especially are esteemed of excellent flavor, and are preferred to those of the plain. I was informed by Lyman Burrell, esq., who has a large ranch in the mountains, and who has also given much attention to grape and fruit culture, that he has uniformly taken the prizes at the State and county fairs. He plants his vines eight feet apart. They are not troubled with frosts, and the ground, he asserts, is much more moist at this season of the year (summer) than it is in the plain. He raises with success the Muscat variety, which, on drying, yield an excellent quality of raisins. Apples, plums, and apricots also do splendidly in his orchards. Vineyards on the mountains are usually

set on the open wild-oat prairie grounds, and they require no underdraining, staking, or irrigation.

Mr. Quimby, ex-mayor of San José, informed me that south of that city artesian borings had not been free-flowing, the water not coming to the surface; that the most powerful fountains are near the bay at the north end of the valley, where, also, they are obliged to bore the deepest in order to reach the main gravel bed or water stratum. His own well at San José had never ceased to flow freely, and to furnish both his own gardens and several neighboring families with an abundant supply of water. Mr. Quimby thinks that it is desirable, if possible, to water the larger fruit-trees in the dry season, for else the roots will penetrate the ground so deeply in search of moisture that afterward, in the rainy season, when the ground is saturated with water, they will be drowned out, having no surface roots. This he mentioned as an inference from his own experience in the cultivation of fruit-trees, referring more especially to apple and peach rather than to pear trees. He thinks also that strawberries should be watered occasionally after the last picking, and that in some soils, at certain seasons, grape-vines should be similarly treated. In San José Valley some irrigate for the raising of garden or kitchen vegetables, but none for the wheat crop.

Very respectfully,

G. N. ALLEN.

SHORT DESCRIPTIONS OF SOME OF THE VALLEYS OF NEVADA.

By Mr. Haskill, of Reno, Nevada.

[On behalf of Mr. Haskill I should state that this short sketch was hastily drawn up by him in answer to a request made through Mr. G. W. Meecham, of Humboldt. I learn that, if desired, he will, by the time your next report is to be published, prepare a more thorough account of the agricultural resources of this young mountain State; but on account of the valuable information contained in these short notes, I have thought it best that they should be placed on record, and have therefore referred them to you.

C. THOMAS.]

Truckee valley extends from a point a short distance below Verde, a station on the Central Pacific Railroad, to Pyramid Lake, distant about sixty miles. It contains some very fine agricultural land. Its width varies from a few rods to several miles; at Truckee Meadows it widens out in circular form, and at this point contains over 10,000 acres of arable land. Elevation at the head of the valley 5,138 feet, gradually descending to 3,933 feet at the foot.

The Truckee River, which courses its entire length, is a beautiful stream of pure water, abounding in trout. Lake Tahoe, its source, is famed for the clearness and transparency of its water.

Washoe Valley, also, in Washoe County, lying mainly ten miles to the south of Truckee Meadows, contains some three or four thousand acres of land which can be rendered tillable by irrigation. Washoe Lake, at the head of this valley, is a sheet of clear water from six to eight miles

in length and about three miles in width. This valley lies along the base of the Sierra Nevada Mountains proper. Several mountain streams flow into it on the west, and it is drained by Washoe Creek, which forms a junction with Hot-Spring Creek and flows into Truckee River. Elevation about 4,600 feet. Climate mild, similar to that of the Middle States.

Humboldt Valley, extending from Humboldt Lake to Humboldt Wells, a distance of three hundred and eighty-four miles, embraces some fine meadow and agricultural lands. Outside of the river-bottoms, which will average a mile in width for a distance of sixty or seventy miles, it is principally sage-bush land, of sandy soil, but very productive when water can be found for irrigation. Numerous streams of water are found upon either side of the valley, rushing down the mountain gorges, all of which sink soon after leaving the mouths of the cañons.

Big Meadows, about five miles above Humboldt Lake, containing about 5,000 acres of land, furnishes great quantities of grass and hay; it contains tillable land, and a fair quality of peat is found here, and in considerable quantities. Elevation, average of that of Humboldt Valley.

Salt Valley is located thirty miles east of Humboldt Lake; contains about 100,000 acres of sage-bush and salt land. It is remarkable and valuable only for its immense salt-bed, which is inexhaustible. Successive layers of fine, crystallized salt are found to the depth of several feet from the surface. Elevation of valley, 4,199 feet.

Black Rock Valley, forty miles west of Humboldt City, contains 350,000 acres of sage-bush and alkali flats, and volcanic matter lines the outskirts. This valley is almost entirely destitute of vegetation. Elevation, 4,900 feet.

Quin's River Valley, forty miles to the east of Black Rock, and distant fifty miles to the northward from Humboldt Valley, contains 115,000 acres, a great portion of which is fine agricultural land. The valley itself has fine blue-joint and red-top grasses, and the surrounding foothills and mountains are covered with an immense growth of bunch-grass and white sage, and constitutes the finest cattle range in the State. Quin's River flows through it, and sinks in Black Rock Valley. General elevation, 4,850 feet.

King's River Valley lies twenty-five miles to the northwest of Quin's River, and contains about 75,000 acres of land. In every respect, except as to extent, the two valleys are alike, elevation being about the same.

Paradise Valley is twenty miles distant, commencing ten miles north from Winnemucca, and contains 125,000 acres. Little Humboldt River enters it near its head and pours down its center. This valley contains 35,000 acres of meadow land, and yields a most luxuriant crop of blue-joint and red-top grasses and white clover annually. Outside of the grass land are large tracts of sage-bush land, which yield almost incredible crops of wheat, oats, barley, and potatoes. The yield of barley is from 50 to 80 bushels per acre. A number of small streams flow from the mountains on either side, and afford abundance of water for irrigation wherever it is needed. About 3,000 acres are under cultivation at the present time, most of which has been tilled for the past six years, and without missing a crop. Various fruit-trees have been set out, and with entire success. In short, the soil and climate render this valley most inviting to the emigrant seeking a place to build up a desirable home. Its elevation is about 4,500 feet.

Pueblo Valley, sixty-five miles northward of Winnemucca, is twenty-six miles in length, and from ten to fifteen miles wide. The foot-hills and surrounding mountains are covered with bunch-grass, while fine

tracts of tillable land are found in and at the mouths of the cañons. A great number of mountain-streams flow down and sink in this valley. In these streams, as well as in King's River and Quin's River, and the creeks and brooks of Paradise Valley, are found the most delicious trout, while the water affords means for irrigation where it is required. Elevation, about 5,000 feet.

Grass Valley, ten miles southeast from Winnemucca, is watered from the cañons on the east and west, and contains 50,000 acres, about 500 of which only are now under cultivation, with the very best success to the husbandman. Wheat, oats, barley, and all kinds of vegetables grow in great abundance, though the amount of surface water is limited. Elevation, 4,300 feet.

Reese River Valley is from eighty to one hundred miles long, and from two to eight wide, through which flows the river from which it takes its name. The river, except in seasons of more than usual snow and rain in the mountains, sinks before it reaches the Humboldt, at a point near Battle Mountain, on the railroad.

Fish Creek Valley, twenty miles west, contains four or five thousand acres of arable land, and west of this is Lone Hill Valley, which contains 100,000 acres of sage-bush land suitable for cultivation, but now being sought after by stock-men for grazing purposes. Elevation, 4,800 feet.

Clover Valley, south of Wells Station, contains about 100,000 acres level land. Some meadow land about Snow Creek and Lake. Elevation, 5,700 feet. Nearly all good farming land, with water plenty.

Thousand Spring Valley, east of Wells Station, contains about 70,000 acres grazing land. Water abundant. Elevation, 5,950 feet.

Grouse Valley, outlet of Thousand Spring, contains some good grazing and meadow land. Elevation, 5,600 feet.

A minute description of each valley would be simply a repetition of words; for all the valleys above named in climate, soil, productions, and general appearance are very much the same. A sufficient supply of water for irrigation is the great want. This difficulty, however, can be obviated by artesian wells. The time is not distant when hundreds of thousands of acres will be brought into subjection by this means, and now, where there is nothing seemingly but a desert waste, broad fields of the cereals and inviting meadows will delight the eye and relieve the present monotony. The apples and peaches in the few orchards in Humboldt County are unsurpassed in their yield and the flavor of their fruit. That there is an abundance of water beneath the surface, only requiring necessity to bring it forth, has already been proven at the two extremes of the great Humboldt Valley. One has recently been bored fifty miles east of Wadsworth, on the line of the Central Pacific Railroad, and is now yielding a constant supply of water, which it sends through the pipe four feet above the surface. Another at Kelton, begun and completed last week, sends up a fine stream several feet above the surface. The expense of boring thus far has proven quite insignificant, which fact, with results already achieved, will influence others in the same direction, and it is not unreasonable to believe, from what has been accomplished, that the great need—water—will be supplied through artesian wells.

EXPERIMENTS IN CULTIVATION ON THE PLAINS ALONG THE LINE OF THE KANSAS PACIFIC RAILWAY.

By R. S. Elliott.

The treeless plains between the Platte and Arkansas Rivers may be said to extend from the ninety-seventh meridian of longitude to the Rocky Mountains. North of the Platte and south of the Arkansas the general features of the country are similar, but for the purpose of this report we need only have in view the region between the rivers. Its drainage is mainly through the Kansas River, the numerous affluents of which afford, in pools or currents, the water-supplies which have enabled the buffalo to sustain himself in all its parts. Along some of the streams there are occasional groves and fringes of timber—ash, box-elder, cedar, cherry, cotton-wood, elm, hackberry, oak, plum, walnut, and willow; some of the species persistent to the mountains, but not in numbers or distribution sufficient to change the character of the country from that of open, treeless plains, rising gradually from about 1,000 feet above the level of the sea at the ninety-seventh meridian to more than 5,000 feet at Denver.

There is great uniformity in the surface of this immense inclined plane. The face of the country presents a series of gentle undulations, but there are no points of much elevation above the general surface, nor any great depressions below it. The geology seems to be in harmony with the surface features, as the earths and rocks of this vast region, five hundred miles in width, range from Lower Cretaceous, (Mudge,) on its eastern border, to the later Tertiaries of the Lake period, (Hayden and Newberry,) near the base of the mountains.

Open on the north to the arctic circle, and on the south to the Rio Grande, with no mountain-ranges or extensive forests to check atmospheric movements, the great plains must necessarily be swept by winds as freely as the ocean. In spring and summer the winds from the southward are most prevalent. In winter the winds are more frequent from the northward. In the autumn they are apt to be more variable, and at the same time of more gentle character. Wind from the west is seldom observed. The winds are often strong, but they cannot be classed with destructive gales. They come with a steady pressure, which may cause a frail building to tremble, but will not overturn it. Tornadoes and hurricanes seem to be unknown. There is no record or tradition of such manifestations. Local thunder-storms and heavy rains, over comparatively limited districts, are experienced as detached phenomena, but are apt to be incidents of a storm covering a large area, and moving eastward. Days of comparative calm and of gentle breezes often occur, when, perhaps, for a week the wind-mill is unable to work the pump at the water-station, but total rest of the atmosphere, except for brief periods, is rare. The climate is propitious to health and to comfort; for although changes of temperature are at times sudden and considerable, yet injurious results seldom follow them.

As we pass westward from the ninety-seventh meridian, the atmosphere is observed to be more arid. Within two hundred miles of the mountains, the deposition of dew is at times so light as to be of little or no service to the vegetation. The annual rain-fall is also less as we go westward, decreasing nearly in the ratio of distance until the divide is reached at and southwest from Cedar Point, in which vicinity there is supposed to be more rain than eastward in the plains or westward

nearer the foot-hills. The natural effect of decreasing precipitation and increasing aridity is in some degree shown in the vegetation. The grama and buffalo grasses continue, together with the sunflower, *solanum*, *euphorbia*, and other plants, which are vigorous, nearly if not quite as far east as the ninety-seventh meridian; but we find that the blue-joint grass of Central and Eastern Kansas is less abundant, and that *cleome*, *ipomea*, cactus, *artemisia*, &c., enter on the more arid scene as if in their chosen home. But no considerable part of the plains between the Platte and Arkansas is so arid as to be destitute of vegetation, although the change in the flora is rather distinctly marked as we pass from the middle of Kansas westward.

Like any other extensive area, the plains exhibit a variety of soils, but the fertile greatly exceed in extent the unfertile districts. Loam, with greater or less mixture of vegetable matter, is the prevailing soil, the proportions of sands and clays differing greatly in different localities. The patches of sand or gravel of meager fertility, or of alkaline clays, unsuited to general plant-growth, are very small in proportion to the whole area, and with irrigation in some parts, and without it in others, the entire region would prove, on trial, to be productive, with as small a share of waste-land as some of the most favored States. The value of the plains for production is more affected by peculiarities of climate than by poverty of soil.

EXPERIMENTS IN CULTIVATION ORDERED.

Twenty years ago the lands available for general agriculture west of the State of Missouri were supposed to lie in a belt of not more than one hundred miles in width, extending north and south. Even when the Territory of Kansas was organized, the whole area west of Missouri and east of the mountains was of doubtful value in public estimation; and emigration was stimulated by political considerations rather than by correct knowledge or appreciation of the country. Beyond the narrow belt, and stretching away to the mountains, was the unfruitful waste, as popularly estimated. Its possible future usefulness for pastoral purposes had been at times suggested, but the day for its actual occupancy, if ever to arrive, was regarded as far distant. The settlers, however, soon ventured beyond the supposed boundary of productiveness; and as they increased in numbers, the area of available lands was found to extend itself westward, as if to meet their necessities. The construction of the railway brought increased emigration, more accurate knowledge of the resources of the country, and a firmer confidence in its future. By 1870 settlements had stretched along the railway to points more than two hundred miles west from the State of Missouri. The pioneer had passed the boundary of the traditional "desert" at the ninety-seventh meridian, and in his march westward had found that the desert, like its own mirage, receded before him. Was his march to continue; and how much farther could soil, temperature, and rain-fall be relied on to reward cultivation? These questions, important to the interests of the general public, as well as of the railway, could best be answered by experiments, and the directors of the company ordered some such experiments to be made.

In the spring of 1870, gardens were made at some of the stations, at distances between two hundred and thirty-nine and three hundred and seventy-six miles west from Kansas City; the farthest westward being at Carlyle Station, 2,948 feet above the level of the sea. Seeds

tried in these gardens germinated well, and the plants, with rude and imperfect culture, grew encouragingly. The results were satisfactory, although the destruction by insects was greatly beyond anticipation. Irish potatoes, for example, made vigorous growth, yet about the time of blooming were destroyed by a species of blister-beetle, (*Epicauta corvina*, Riley,) which proved to be a more formidable enemy than even the Colorado potato-bug. Spring-wheat matured merchantable grain at Carlyle.

In the summer and fall of 1870 a few acres were broken at each of the three following stations, on the Kansas Pacific Railway, distant from Kansas City and above the level of the sea as follows:

Stations.	West from Kansas City.	Above sea-level.
	Miles.	*Feet.*
Wilson, (now Bosland)	239	1,586
Ellis	302	2,019
Pond Creek	422	3,175

These places are in the western half of the State of Kansas. All are in the present buffalo range; all are in the region of short grasses; all are in the open, treeless plains, beyond the limits heretofore assigned to settlements.

Wheat, rye, and barley were sown at each of these stations in the fall of 1870; at Pond Creek, September 28; at Ellis, October 20; and at Wilson, November 11. At Pond Creek the rye grew finely and matured a fair crop; the wheat and barley were partially winter-killed, but the surviving plants made heads of the usual length, well filled with grain of good size and quality. At Ellis the promise of all the grains was excellent until the 1st of June, when a hail-storm of unusual severity prostrated every stem. At Wilson the grains all did well. The president and the secretary of the Missouri State board of agriculture (who, in company with members of the board, visited the stations in June) say in their report: "We found wheat, rye, and barley sown November 11, 1870, [at Wilson,] equal to if not beyond the average crop of any part of the Union." And of Pond Creek they say: "The rye, sown 28th of September, on raw ground, would rate as a good crop in Missouri or Illinois; and of the winter-wheat and barley, the plants which had survived the winter were heading out finely. Rye may be regarded as a valuable crop to the west line of Kansas, (without irrigation;) and further trials of wheat and barley of the more hardy kinds will, in all probability, be successful."

Trials of grass-seeds at the stations named have shown that sorghum, lucerne, timothy, clover, and Hungarian grass may be regarded as future forage crops on the plains; the first and last being the most promising. Maize can be grown for fodder at each of the stations, and for its grain at Wilson and Ellis. At Pond Creek, sorghum made a good length of stalk and matured fine panicles of seeds. At Ellis and Wilson the stalks reached a height of nine to ten feet, and abundance of seeds were matured. This plant will be found to be of great value in Western Kansas and Eastern Colorado, if its usefulness for fodder has not been greatly overrated. In the dry atmosphere of the plains, the stalks could probably be dried so as to avoid the souring of the juice, on which, in Illinois, an objection has been raised to its use as a fodder-plant.

TREE-SEEDS.

There were planted at Wilson tree-seeds as follows:

Fall of 1870.—Ailantus, chestnut, oak, peach, pecan, piñon.

Spring of 1871.—Ailantus, catalpa, elm, locust, honey-locust, silver-maple, osage-orange, walnut.

All these seeds, except the piñon, (nut-pine of New Mexico, *Pinus edulis*,) have done remarkably well.

Seeds of ailantus, catalpa, locust, honey-locust, and osage-orange were tried at Ellis with encouraging prospects, when most of the seedling trees were destroyed by the hail-storm of the 1st of June. Seeds of ailantus, sown broadcast during the first week in June, came up well, and the little trees came safely through the summer.

Seeds of ailantus sown at Pond Creek resulted in a moderate growth of trees, of which a large proportion survived the summer.

The experiments with tree-seeds, though very limited, have sufficed to show that trees may be grown from seed without irrigation, to the west line of Kansas, and in all probability to the base of the mountains.

Cuttings of cotton-wood, Lombardy and white poplar, and white and golden willow, were tried at Wilson and did well in that locality. Cuttings of cotton-wood and the willows were also tried at Ellis with a measure of success.

TRANSPLANTED TREES.

Trials were made at Wilson of transplanted trees of the following kinds:

EVERGREENS.

White pine.................*Pinus strobus.*
Scotch pine.................*P. sylvestris.*
Austrian pine.................*P. Austriaca.*
Corsican pine.................*P. laricio.*
Norway spruce.................*Abies excelsa.*
Red cedar.................*Juniperus Virginiana.*

DECIDUOUS.

Ailantus.................*A. glandulosa.*
Ash.................*Fraxinus Americana.*
Box-elder.................*Negundo aceroides.*
Catalpa.................*C. bignonoides.*
Chestnut.................*Castanea vesca.*
Cotton-wood.................*Populus monilifera.*
Elm.................*Ulmus Americana.*
Honey-locust.................*Gleditschia triacanthus.*
European larch.................*Larix Europea.*
Linden.................*Tilia Americana.*
Silver-maple.................*Acer dasycarpum.*
Sycamore-maple.................*A. pseudo-platanus.*
Osage-orange.................*Maclura aurantinea.*
Lombardy poplar.................*Populus dilatata.*
White poplar.................*P. alba.*
Tulip-tree.................*Liriodendron tulipifera.*
White willow.................*Salix alba.*
Golden willow.................*Salix alba*, (var.)
Walnut.................*Juglans nigra.*

The foregoing trees, whether transplanted or from seeds or cuttings, have done well at Wilson, making growth equal to what is usual in Eastern Missouri or Illinois. Reverend E. Gale, one of the regents of Kansas State Agricultural College, examined the trees on the 18th of August and reported measurements as follows:

From seed.—Ailantus, 24 to 30 inches; catalpa, 3 to 12 inches; chestnut, 4 to 12 inches; elm, 10 to 20 inches; locust, 36 to 48 inches; honey-locust, 16 to 24 inches; silver-maple, 12 to 24 inches; oak, 8 to 10 inches; osage-orange, 12 to 30 inches; peach, 24 to 30 inches; pecan, 4 to 9 inches; walnut, 10 to 12 inches.

From cuttings.—White poplar, 12 to 27 inches; Lombardy poplar, 24 to 36 inches; cotton-wood, 18 to 24 inches; white willow, 24 to 36 inches.

Transplanted.—Ailantus, 48 to 60 inches; ash, 10 to 16 inches; box-elder, 36 to 40 inches; catalpa, 12 to 24 inches; chestnut, 8 to 14 inches; cotton-wood, 36 to 60 inches; elm, 20 to 30 inches; honey-locust, 36 to 42 inches; larch, 6 to 12 inches; linden, 9 to 18 inches; silver-maple, 24 to 30 inches; sycamore-maple, 12 to 24 inches; osage-orange, 12 to 36 inches; peach, 30 to 36 inches; white poplar, 24 to 36 inches; Lombardy poplar, 24 to 36 inches; tulip-tree, 8 to 10 inches; willows, 36 to 48 inches; walnut, 6 to 8 inches.

Mr. Gale says: "The evergreens have nearly all lived, and have made a growth of from 4 to 8 inches. All have done well. There is certainly nothing in the appearance of these trees to discourage the planting of evergreens in Kansas." It is proper to state that the catalpa-seed was sown broadcast on ground which had been broken the November previous and was not replowed. Seedling walnuts were grown by putting the seed under fresh-turned sod. None of the trees had the care or cultivation usual in nurseries.

At Ellis the same transplanted trees were tried as at Wilson, except red cedar and cotton-wood. The result was encouraging, although the chestnut, larch, and Norway spruce may be said to have failed on this first trial, and some others were less vigorous than at Wilson. The hail-storm of 1st June greatly damaged the trees, cutting off the leaves and shoots and splitting the bark; yet a large proportion of the deciduous class made a fair growth, and about 50 per cent. of the pines survived. Of ailantus, ash, catalpa, honey-locust, and white poplar planted at Ellis every tree survived, and nearly all of the box-elder, elm, silver-maple, osage-orange, Lombardy poplar, and black walnut.

At Pond Creek the growth of some kinds of trees was highly encouraging. Ailantus, ash, box-elder, catalpa, honey-locust, and osage-orange have done best, and promise well for the future. Elm and black walnut made moderate growth, and seem to have established themselves. The willows, the poplars, and the silver-maple did not come up to expectation. European larch and most of the evergreens failed; but a few of the pines lived through the summer, and in another season will probably do well. The trees at Pond Creek are in one of the most forbidding spots of all the plains. At the new station, Wallace, about two miles eastward, and on higher ground but with different soil, silver-maple and Lombardy poplar seem to do much better than at Pond Creek.

NO IRRIGATION.

The experiments were all without irrigation. Except to soak some of the seeds, or to puddle the roots of the trees as they were set out, not one drop of water was applied by human agency. The trees had not the benefit of good care and cultivation; they were not aided by mulching the ground; nor had they any shade or shelter from the winds. All

the conditions of the experiments were such as the ordinary farmer may easily imitate.

One object was to test the possibility of growing trees and other plants on the plains depending on the rain-fall alone. It was deemed important to show that the settler in the open waste may adorn his home with trees; may grow fruits and timber; may raise grains and other vegetable food for his family and his live stock without resort to expensive processes of artificial watering. So far as we may judge from a single season, the object has been accomplished; and it is not doubted that future years will sustain the promise of the past season.

SETTLEMENTS ON THE PLAINS.

Within the past two years settlers, in families and colonies, have spread westward, along the line of the Kansas Pacific Railway, and also on streams north and south of the road, nearly to the one hundredth meridian. The purpose is generally to grow and deal in cattle and other live stock, and this purpose will be greatly aided by the capability of the country to produce grains and other products of general agriculture. The first settlers keep near the streams, as a general rule, for the convenience of water ready at hand and the limited supply of timber. If we look backward twenty-five years and reflect on the westward extension of settlements during that time, we must see that the causes which have pushed the "frontier" nearly three hundred miles west from the mouth of the Kansas River are yet in active operation, aided by potent agencies not then in existence. *Then* the locomotive was unknown west of the Mississippi; *now* there are in Iowa, Missouri, Nebraska, and Kansas thousands of miles of railroad. *Then* the entire population of the United States was only about twenty-one millions; *now* it is over forty millions. It is safe to say that the forces operating to throw population westward, taking into consideration facilities of transportation, are three times as powerful as they were twenty-five years ago. The result will be a gradual spread of people over the great plains, arranging their pursuits and modifying their habits to suit the capabilities of the country and the necessities of their respective localities.

EFFECT ON CLIMATE.

It is a bold assumption to say that the spread of settlements over the plains is to materially affect the climate. Yet it is not unreasonable to expect some degree of amelioration. Every house, every fence, every tree which civilized communities may in the future establish in those vast, open areas, will aid, in some measure, to check the sweep of the winds. Every acre broken by the plow will retain a greater amount of moisture after rains, and for a longer time, than the unbroken prairie. The genial rains of spring and summer will evaporate with less rapidity, and there will be a greater degree of humidity in the atmosphere, heavier dews, and possibly more frequent showers. Even if the annual average of rain-fall shall not be increased, the chances are that it will be more evenly distributed. If we may judge by the experience of other parts of the world, where the destruction of forests has operated to dry up fountains, we may reasonably expect that the breaking up of the surface by the plow, the covering of the earth with taller herbage, and the growth of trees, will all tend to the development of springs where now unknown, and to render streams perennial which are now intermittent. Thus the gradual spread of inhabitants over the plains will tend to enlarge their capabilities and to render them more habitable.

PART III.

PALEONTOLOGY.

FOSSIL FLORA.—BY LEO LESQUEREUX.

I.—ENUMERATION AND DESCRIPTION OF THE FOSSIL PLANTS, FROM THE SPECIMENS OBTAINED IN THE EXPLORATIONS OF DR. F. V. HAYDEN, 1870 AND 1871.
II.—REMARKS ON THE CRETACEOUS SPECIES DESCRIBED ABOVE.
III.—TERTIARY FLORA OF NORTH AMERICA.

ON THE GEOLOGY AND PALEONTOLOGY OF THE CRETACEOUS STRATA OF KANSAS.—BY E. D. COPE, A. M.

I.—A GENERAL SKETCH OF THE ANCIENT LIFE.
II.—GEOLOGY.
III.—SYNOPSIS OF THE FAUNA.

ON THE VERTEBRATE FOSSILS OF THE WAHSATCH GROUP.—BY E. D. COPE, A. M.

ON THE FOSSIL VERTEBRATES OF THE EARLY TERTIARY FORMATION OF WYOMING.—BY PROF. JOSEPH LEIDY.

PRELIMINARY LIST OF THE FOSSILS COLLECTED BY DR. HAYDEN'S EXPLORING EXPEDITION OF 1871, IN UTAH AND WYOMING TERRITORIES, WITH DESCRIPTIONS OF A FEW NEW SPECIES.—BY F. B. MEEK.

PALEONTOLOGY.

FOSSIL FLORA.

COLUMBUS, OHIO, *February* 28, 1872.

DEAR SIR: In accordance with your instructions I have prepared the following report on the specimens of fossil plants obtained in your geological explorations of 1871. I regret that the time allowed to me for the examination of such a large number of specimens, (more than three hundred,) and the preparation of the report, was too short. This may account for, if not excuse, the deficiency of this paper.

The first part of the report contains the descriptions of eighty species of fossil plants, mostly of the Tertiary formations. To obviate the want of plates and figures, I have quoted largely from already described and figured species, either analogous or identical, this being the best way to give an idea of the forms of leaves, always more or less obscurely conceived from mere descriptions.

The general remarks on geographical, stratigraphical distribution, typical comparisons, &c., which form the second part of the report, are presented as a mere summary of questions which should be elucidated with more details when your fossil plants of the recent formations are published in a general report and the descriptions illustrated with figures.

Very respectfully, yours,

L. LESQUEREUX.

Professor F. V. HAYDEN, *Washington, D. C.*

I.—ENUMERATION AND DESCRIPTION OF THE FOSSIL PLANTS, FROM THE SPECIMENS OBTAINED IN THE EXPLORATIONS OF DR. F. V. HAYDEN, 1870 AND 1871.*

1. HENRY'S FORK.

Hard silicified limestone, with indistinct remains.

PTERIS PENNÆFORMIS, Heer. A number of broken specimens of the fern referable to this species, have been re-examined, without affording more evidence to what has been said in the former report, p. 384. It differs from the following species, found also on broken specimens of this locality, by its thicker secondary veins, more obliquely attached to the medial nerve, and by its entire borders.

BLECHNUM GÖPPERTI, Etting, (Flor. Bil., p. 14, Pl. iii, Fig. 1–4.) Fragments of linear leaves, half an inch broad, with dentate borders; secondary veins nearly in right angle to the thick medial nerve, parallel, forking once near the base, and much thinner than those of the former species. Though the specimens show mere fragments of leaves, the specific characters are well marked.

A third species of fern is preserved on the shales of this locality. It

* See Report of the Territories, 1870, p. 384.

is a single small oval leaflet, 12 millimeters long, 6 millimeters broad, rounded to the point and to the base, with narrow but distinct medial nerve, and secondary veins, oblique, slightly arched to the borders, forking twice. The base of the nerve is abruptly bent to one side, as if it had been joined to a main *rachis*, or as a lobe of a compound leaf.

PHRAGMITES OENINGENSIS, Al. Br. Represented by broken stems, with distinct nervation, obscure articulations, and scars of branches bearing the characters of this species.

Fragments referable to the genus *Cyperites* and to the genus *Calamopsis*, (?) as described in my former report, *loc. cit.*, p. 384.

2. MUDDY CREEK AND BLAKE'S FORK.

No remains of other species but of those described in the former report have been discovered in the examination of new specimens of these localities. *Aspidium*, named *A. pulchellum*, or *A. Fischeri*, Heer, belongs to this last species; and as far as can be ascertained from fragments of glumaceous leaves, the species considered as *Carex tertiaria*, (?) Heer, *loc. cit.*, p. 384, is right.

3. BARRELL'S SPRINGS.

The matter imbedding fossil remains of this locality appears under three different aspects: 1st. A ferruginous, reddish, hard clay-shale, with few remains of trees, *Sequoia*, *Acer*. 2d. A soft, laminated shale, passing downward to layers of coaly matter, formed of broken pieces of grasses, ferns, &c., all herbaceous plants, with floating rootlets. 3d. A soft, yellow clay, apparently a bottom clay, with roots of *Equisetaceæ*. The succession of deposits from bottom upward is marked by the substance of the shale as by the kind of plants which they have preserved.

LYGODIUM NEUROPTEROIDES, Lsqx, (Dr. Hayden's Report, 1870, p. 384.) Separate leaflets only, with fragments of stems of the same species, are abundant in the shales. Leaflets bifid, trifid or quadrifid, with linear lanceolate obtusely pointed divisions, 4 to 8 decimeters long, from the obconical base of the leaflets to the point of the longest lobes. The leaflets are divided, from below the middle, in lobes irregular in size, the lateral ones being generally shorter, all obliquely diverging with more or less obtuse sinuses and entire or slightly wavy on the borders. Sometimes they are enlarged at the point and emarginate in two short, obtuse lobes. The nervation is simple for each division of the leaflets, the medial nerve of each remaining distinct to the base and there, being separated by secondary flabellate veins, which higher up come out from the medial nerve in a very acute angle, and remain nearly parallel to it before curving to the borders. The lowest veins are three to four times dichotomous, the superior ones only twice, and so close are they to each other that, along the borders, 75 to 80 veinlets are generally marked in one inch. The areas are filled by square or pentagonal *areolæ*, very small but distinct. As yet few fossil species have been referred with sufficient evidence to this fine genus. *Lygodium cretaceum*, Debey and Etting., is from the Cretaceous formations of Belgium. Four other species are described by Heer, from the Miocene of Switzerland, and one from Oeningen.

EQUISETUM HAYDENII, *sp. nov.* Rhizoma, 1½ to 2 decimeters broad, irregularly striate, articulated; articulations distant, bearing round obovate tubercles, 14 millimeters broad, 2 centimeters long, attached 8 to

10 around the articulations. These tubercles, joined to each other like strings of beads, radiating from the rhizoma, are slightly more elongated outside, abruptly rounded or more inflated inward, regularly and narrowly striated as well as the rhizomas, but scarcely, if at all, wrinkled. At a distance from the point of connection to the rhizoma they become more elongated, passing here and there to mere cylindrical filaments or rootlets, which appear to divide in radicles. The point of union of these tubercles, either to each other or to the rhizoma, is marked by comparatively large scars, (5 millimeters wide,) representing a double ring with a central point. This fine species, known as yet only from its rhizoma and its divisions, resembles *Equisetum arcticum*, Heer, (Fl. Arc., 2, p. 31, Pl. i, Fig. 2,) from Spitzbergen, and still more, at least by the form of the tubercles *E. Parlatori*, Heer, as figured by Unger, in Sill., Pl. i, Fig. 5, differing, however, from both by the broader, regularly striated rhizoma, not inflated at the articulations, and by the form and size of the tubercles. No other fragments referable to any species of *Equisetum* have been preserved in the shales of this locality.

TAXODIUM TINAJORUM, (?) Heer. The specimen has two branchlets of *Taxodium*, parallel to each other, apparently divisions of the same branch. One bears long, crowded, linear leaves like those of this species, as figured in Heer's Fl. Arc., 2, p. 22, Pl. i, Fig. 3, from Alaska; the other has more distant and broader leaves, somewhat enlarged in the middle, or narrowing at the base like those of *Taxites Olriki*, Heer, *loc. cit.*, Pl. i, Fig. 8. The substance of the leaves is, in both fragments, of the same thickness, the surface smooth or shining, the branches comparatively thick and flat. In the upper part of the fragment compared to the last species of Heer, the leaves become longer from the base upward, as in the figure of *T. Olriki;* our specimen, therefore, appearing to represent both species.

PHRAGMITES OENINGENSIS, Al. Br. The shales of this locality are covered by a quantity of much-divided roots and rootlets, with thread-like branches of the same form as those figured by Etting., Flor. Bil., Pl. iv, Fig. 7 *b*. With them are mixed fragments of rhizomas, of stems and of leaves of the same species, which are well characterized by their nervation, as marked in Heer's Fl. Ter. Helv., Pl. xxiv, Fig. 5 *b*, enlarged.

POACITES LÆVIS, Heer. As remarked in Dr. Hayden's Report for 1870, p. 385, this species is represented by many fragments of the culm and of the leaves, identical in characters with the author's description and figures in Fl. Tert. Helv., Pl. xxv, Fig. 10 *a*, *b*, *c*, and Pl. xxvi, Fig. 7 *a*. The culm is about 7 millimeters wide, nearly smooth, with close undistinct striæ; the leaves, slightly narrower, are marked by about 10 more distinct smooth lines.

CYPERUS (!) BRAUNIANUS, (?) Heer., (Fl. Tert. Helv., p. 72, Pl. xxii, Fig. 6.) There is scarcely any doubt on the identity of this species, represented like the former by numerous though small fragments. The stems are generally small. One of them bears attached to its curved base or rhizoma, some oval tubercles with round small scars like those of Fig. 6, Pl. xxii, of Heer's *loc. cit.*

CYPERITES DEUCALIONIS, Heer. Mentioned in Dr. Hayden's Report for 1870, p. 384, with fragments of leaf of a *Sabal* referable to *S. major*, (?) Ung.

SPARGANIUM, (!) species. Part of a dichotomous stem, $1\frac{1}{2}$ centimeters wide, with the branches half as broad, distinctly marked lengthwise by regular thin veins, separated by three undistinct very thin veinlets, and marked crosswise by obscure less regular lines, indicating the internal

structure of the stem. No remains of leaves, fruits, or flowers have been found in connection with the fragments of stem, and therefore the species is undetermined. It may be referable to *Sparganium Valdense*, Heer, which it resembles by the nervation and the mode of branching, as seen in Fl. Tert. Helv., Pl. xlvi, Fig. 6 *b*.

ACER, species. Is represented, like the former, by a single fragment too incomplete for specific determination. The round, cordate base only, with a small part of the middle of the leaf and its nervation, is preserved. It appears to be of the same type as *Acer Sismondæ*, Gaud., (1st Mem., Pl. 13, Fig. 4,) agreeing with this last figure for the outline of the leaf and for the nervation, and by its size comparable to Fig. 21, Pl. i, of the 4th Mem., of the same author. I mention this leaf because it is the only fragment of an arborescent dicotyledonous species preserved on the shale of this locality.

4. ELKO STATION.

A yellowish white calcareous fine-grained shale, hardened by metamorphism. Plants preserved in broken, small, mixed fragments.

PHRAGMITES OENINGENSIS, Al. Br., in numerous fragments of leaves, stems, and rhizomas.

POACITES LŒVIS, Heer. Represented like the former, by a great number of broken leaves, with smooth surface, often without trace of veins. The blades are mostly narrower than in the figures of this species, in Heer's *loc. cit.;* intermediate in width between those of *Poacites lœvis* and *P. augustus*, Heer, (Fl. Ter. Helv., Pl. xxvi, Fig. 7 *a* and *b*,) or even as narrow as in the last-named species.

QUERCUS SEMI-ELLIPTICA, Göpp., (Schossnitz, Fl., p. 15, Pl. vi, Figs. 3, 4, 5.) There are four specimens of this species, one of which only represents an entire leaf with all the specific characters. The form of the leaf, with its slightly unequal base, the nervation, the teeth of the borders, are exactly similar to Fig. 3, *loc. cit.* The leaf is only smaller, half an inch long, one-fourth of an inch broad. Of the other specimens, all fragmentary, one only indicates a somewhat larger leaf. Professor Heer refers (Fig. 4, quoted above) to *Planera Ungeri;* and, indeed, our specimens much resemble some forms of this polymorphous species, and might be referred to it but for the base of the leaves narrowed to the petiole by a short curve. The nervation, also, is somewhat different, the secondary nerves branching often downward above the middle, as in species of *Ulmus*, and the lowest secondary veins curving near the borders and along them, though their angle of deviation is about the same (40°) as in the upper ones, which go straight to the point of the teeth. The veins and veinlets are flat and deep, nervilles not quite distinct, but marked as perpendicular or oblique to the veinlets.

5. WASHAKIE STATION NEAR BRIDGER'S PASS.

A calcareous and arenaceous stone, hardened by metamorphism, dark-gray, irregularly breaking. Remains of plants preserved in large distinguishable fragments, sometimes rolled or even flattened in a direction crossing the horizontal layers of the stone.

RHAMNUS INTERMEDIUS, *sp. nov.* Leaf 6 centimeters long, not quite 2 centimeters wide, narrowly oval, lanceolate and oblanceolate, with entire margins tapering downward to a short petiole, (?) (petiole broken,) medial nerve half round, strong, secondary veins oblique, (35°,) close to each other; 16 pairs from base to point, thick, curving near the

borders, straight to the point of curve. By its closely approached secondary veins this species is like *Rhamnus obovatus*, Lesqx., (Am. Jour. Sci., vol. XLV, p. 207,) but differs by the greater thickness of these veins, which more abruptly curve near the borders, and the more lanceolate form of the leaves. From *Rhamnus salicifolius*, Lesqx., *loc. cit.*, p. 206, to which it is also comparable by its form, our leaf differs essentially by its closer nervation.

CORNUS ACUMINATA, Newby. One of our specimens agrees with Newberry's leaf as figured, (Pl. xx, Fig. 3, ined.,) the secondary veins only being less numerous and ascending along the borders in a less acute angle. As the same differences are marked also between the three specimens figured by the author, they do not authorize a specific separation. The leaf seems to have been of thin texture, at least not coriaceous; the medial, like the secondary veins, are comparatively narrow, not as distinctly marked as they are generally in species of this genus. Another specimen of the same locality represents Fig. 2 of the same plate. It is broken and not as well preserved as the former.

POPULUS LATIOR var. TRANSVERSA, Heer. A leaf of the same form, size, nervation, and marginal division as the one represented in Heer's Fl. Ter. Helv., Pl. lvii, Fig. 6. It is also equally runcinate.

FICUS TILIÆFOLIA, Al. Br. The specimen represents an entire leaf, less the base and the point. It is broadly cordate, lanceolate-pointed, with entire borders, medial and lateral veins strong, these mostly opposite, the lowest much divided by inferior branches going out at an open angle from the medial nerve and then curving upward in a half circle and ascending along the borders; nervilles perpendicular to the secondary veins, strong, continuous. Though somewhat broken, the specimen represents evidently this species as figured by Heer, (Fl. Ter. Helv., Pl. lxxxiii, Fig. 7.) The leaf in its broadest part is 3 inches wide.

JUGLANS RUGOSA, Lesqx. Broken specimen.

PLATANUS HAYDENI, (?) Newby. Also an incomplete specimen, referable by its size and nervation to this species. Its base, however, is not decurrent to the petiole, but merely wedge-shaped. The fragment of this leaf is 6 inches long.

MAGNOLIA, (!) species. The middle part of a large leaf of Magnolia, 2½ inches wide in the middle; the upper and lower part being broken. The leaf is apparently broadly ovate-lanceolate, resembling by its form and the direction of the secondary veins *Magnolia Inglefieldi*, Heer, in Fl. Arc. I, Pl. xviii, Figs. 1 to 3. The medial nerve is narrow though deep, the secondary veins diverging more or less under an average angle of 30°, and at variable distance, some simple, some forking from above the middle, separated here and there by thinner intermediate secondary veins.

POPULUS ARCTICA, Heer. Identical with the form figured by the author in Arc. Fl. I, Pl. v, Fig. 3; the borders being merely undulate.

LIQUIDAMBAR GRACILE, *sp. nov.* Leaf comparatively small, a little more than 2 inches long, broader than long, palmately, nearly equally five-lobed; lobes conical-pointed, separated by obtuse sinuses, the lowest nearly continuous to the truncate or slightly oblique base; petiole as long as the leaf. This species might be referable to the genus *Acer* by its nervation, which resembles that of *Acer dasycarpon*, Ehr. It has only three primary nerves, diverging from the top of the petiole, and each of the lateral ones divides, near the middle or at a distance from the base, in two branches of equal size, which both support one of the

lateral lobes and ascend to its point. The secondary veins as seen near the point of the middle division are close to each other, curving along the borders, but the areolation is obsolete. The border of the leaf is entire, and though the lobes on one side are curved down into the stone, and on the other side partially erosed, the outlines of the whole leaf are easily made out.

QUERCUS ÆMULANS, *sp. nov.* A large leaf, 4 inches long, 2 inches wide, broadly oval, (point and petiole broken,) gradually curving to the base, with borders equally dentate from below the middle upward, entire or merely undulate downward; medial nerve narrow, deep; secondary veins irregular in distance and direction, (angle of divergence about 40°,) slightly curving upward, nearly simple, craspedodrome; a species not satisfactorily known as yet, related by the form of the leaf to *Quercus furcinervis*, Heer, as figured in Fl. Arc., I, Pl. xlv, Fig. 1 *d*, but far different by the irregularity of the secondary veins curved in ascending to the borders and by the sharp teeth turned up from an obtuse sinus, as in the leaves of our *Castanea pumila.* The leaf is twice as large as that of Heer.

JUGLANS ACUMINATA, (?) Heer. The point of a leaf, from the middle upward, merely differing from the general form of the species by the longer tapering point of an apparently narrow leaf. Probably represents an inferior leaflet of this species.

6. WASHAKIE GROUP, CRESTON, W. T.

Soft, greenish clay, a kind of soapstone, easily cut with the knife.

ACORUS BRACHYSTACHYS, Heer, (Fl., Spitz., p. 51, Tab. viii, Figs. 7 and 8.) A fragment of the same size and form as the branch figured on the left side of Pl. viii, Fig. 8, bearing also a small sessile ear of the same size. In one specimen part of the seeds have been detached from the receptacle, and thus the spiral direction of the axis and the mode of attachment of some of the seeds are distinctly seen.

PALIURUS COLOMBI, Heer. (Fl. Arc., I, p. 122, Tab. xvii, Fig. 2, and Pl. xix, Figs. 2 to 4.) Numerous leaves of the different forms representing this species and other varieties are preserved on our specimens. The smallest leaf is 22 millimeters long and 14 millimeters broad, ovate, lanceolate-pointed, narrowed by a curve to the petiole. This form has generally the borders marked by one or two obtuse teeth above the middle. The more general form of the leaves is broadly ovate, abruptly narrowed to an obtuse point, with the base rounded to a long petiole and the borders entire, generally equilateral, but sometimes more enlarged on one side. The nervation is the same as marked by the author, *loc. cit.* It has three primary nerves, the lateral ones ascending to three-quarters of the leaves, curving inward and there anastomosing with branches of the medial nerve. But when the leaves enlarge, they bear at the base a pair of thinner marginal veins, which in still broader leaves become as thick as the primary lateral ones, ascend in the same direction, and give the leaf the same appearance as that of some leaves of *Populus arctica.* Our specimens have branches of the same species, bearing petioles of leaves and spines; also pieces of bark with oval scars of spines close to each other, and small oval seeds or nutlets, surrounded upward with an oval, flattened border, like a narrow wing. The areolation is rendered distinct by the erosion of the *parenchyma* of some of our leaves.

7. MEDICINE BOW COAL-BEDS.

Fine-grained, grayish shale, separating in horizontal layers; remains of plants distinct.

PHRAGMITES OENINGENSIS, Heer. A fine stem, with articulations, scars of branches, &c.

POPULUS LATIOR var. CORDIFOLIA, Al. Br. The same form as that from Alaska, in Heer's Fl. Al., p. 25, Pl. ii, Fig. 4.

POPULUS ARCTICA, Heer. Same form as in Fl. Arc., I, Pl. v, Fig. 11.

PLATANUS GUILLELMÆ, Göpp. As in Heer's Fl. Arc., II, Pl. xlvii, Fig. 3; a species represented by our specimens in many of its varieties.

PLATANUS HAYDENII, Newby., (Pl. xx, Fig. 1, ined.) The form of this leaf is like that of *Platanus heterophylla*, Newby., in Pl. xxi, Fig. 1, ined., with the same nervation also; but it has the obtuse, large teeth of *P. Haydenii*; the leaf is, however, much smaller; may be referable to *Platanus Guillelmæ.*

8. GREEN RIVER GROUP, HIGH ON HILLS FROM RIVER.

Coarse-grained, yellow, hard limestone shale, with few remains of plants.

CEANOTHUS CINNAMOMOIDES, *sp. nov.* Leaf narrowly elliptical, pointed to the base, distinctly and distantly crenulate upward from above the base; medial nerve slightly thicker than the lateral ones which ascend from the base of the leaf, and nearly parallel to the borders to apparently to three-fourths of the leaf, which is obliquely broken above the middle. The medial nerve has no trace of secondary veins as high as it is discernible, but merely strong, nearly horizontal nervilles, very distinct, like the netting of the areolation; much like *Ceanothus Ziziphoides*, Ung., chloris especially as figured by Heer, (Fl. Ter. Helv., Pl. cxxii, Fig. 25.) It differs by the borders, more distantly crenulate in the upper part only, and by the base of the leaf, which is entire and does not pass downward beyond the point of divergence of the lateral veins.

CARYA HEERII, Etting. A few fragments of leaves of this species, especially of the form and nervation marked in Fl. Ter. Helv., Pl. xcix, Fig. 23, *a*.

9. JUNCTION STATION, SUMMIT OF HILLS, NEAR DIVIDE, NORTH OF SNAKE RIVER.

Hard silicified limestone.

PLATANUS GUILLELMÆ, Göpp.

POPULUS ARCTICA, Heer. Both represented by mere fragments.

10. POINT OF ROCKS STATION, UNION PACIFIC RAILROAD.

Brown ferruginous clay, with small fragments of plants, mostly undeterminable.

CYPERITES. Numerous fragments heaped in various directions, referable to *Cyperus Deucalionis*, Heer; *C. Chavanensis*, Heer; and *C. angustior*, Heer. (?) None distinct enough for identification.

FAGUS ANTIPOFII, Heer, (Fl. Alas., p. 30, Pl. vii, Fig. 4 to 8.) An apparently ovate, long-pointed leaf, with straight, nearly parallel, slightly diverging, oblique secondary veins. These are simply craspedodrome, and the point where they reach the borders is marked by very small

mucronate teeth. A few of these veins branch near the point as in *Fagus Deucalionis*, Ung.

Small fragments of *Juglans* and of *Platanus*.

11. COALVILLE, UTAH.

A single specimen from this locality; a piece of hard metamorphic sandstone, with scattered, small fragments of dicotyledonous leaves, none of which are large enough to be recognizable even for generic reference.

12. CARBON STATION, UNION PACIFIC RAILROAD, WYOMING TERRITORY.

Fine-grained shale, same color and compound as at Medicine Bow.

PLATANUS ACEROIDES, Göpp. A whole large leaf, far different from the leaves of the following species by the borders rounded to the petiole and not tapering, by the angle of the secondary veins more open, and by the form of the much broader leaves.

PLATANUS GUILLELMÆ, Göpp. Among others there is a large specimen covered with nearly entire leaves of this species, showing its various forms. The leaves are all more or less trilobate, with short lateral lobes; the base is more or less open, cuneiform to the petiole and entire, always descending lower than the base of the first pair of secondary veins. The secondary veins are narrow, but well marked; the texture of the leaves is rather thin than coriaceous; the fibrilles somewhat obsolete, but in some leaves very distinct. Specimens of this species are not distinguishable from the following.

PLATANUS HAYDENII, Newby. Same leaf as described from Medicine Bow, p. 289.

CARPOLITHES COCCULOIDES, (?) Heer, (Fl. Arc., II, p. 484, Pl. lii, Fig. 9 and 9 *b*.) A small obovate fruit, obliquely truncate at its narrowed base, about 1 centimeter long, nearly as broad, evidently a thick drupe or *achenium*, as the stone is excavated around it on one side. It resembles the fruit of an *Acer*, without the wing, or could be compared to the fruit of a *Prunus* but for its unequal base, more contracted on one side than on the other, much like Heer's figure, *loc. cit.*

13. SAGE CREEK, MONTANA TERRITORY.

Fine-grained, buff-colored, hard, laminated shale, split in thin layers, with few fragments of vegetable remains and some scales of fishes.

A FERN, undeterminable fragments, of exactly the size and form as the one published by Heer, (Fl. Arc., II, Pl. xlviii, Fig. 3 *b*,) and merely mentioned as *Fern* from North Greenland. The surface is covered with a pulverulent coaly matter, obliterating the nervation. The medial nerve only is visible on our specimen, while it is not seen on the fragments obtained from Greenland.

SEQUOIA HEERII, *sp. nov.* We have numerous and well-preserved specimens of this species. It agrees well enough with the small forms of *Sequoia Langsdorfii*, Brgt., figured in Fl. Arc., I, Pl. ii, Fig. 15, but differs evidently by shorter and narrower, more distant leaves, all narrowed above the decurring base, and, as observed upon the same branches, either pointed or obtuse. Some even are enlarged upward and obtuse; some abruptly pointed. The cone is borne on long, naked branches, marked with undistinct scars of scales; its form is nearly round, slightly flattened, resembling the cone of *S. Langsdorfii*, in

Fl. Arc., I, Pl. ii, Fig. 2, but nearly twice as large. To this species is referable the form which Heer, in Fl. Alas., p. 23, Pl. i, Fig. 10 and 10 *b*, considered as possibly a variety of *S. Langsdorfii*, and perhaps also the branches figured as *S. Langsdorfii*, (?) by Newberry, Pl. xi, Fig. 4, ined. In this, however, the base of the leaves is decurrent, without being narrowed.

There is still a great deal of uncertainty about the relation of the fragments of coniferous species, published from our Tertiary strata by the authors quoted above. The remarks of Dr. Newberry, concerning the deciduous appearance of leaves and branchlets of his species, are, in part, applicable to our fragments from Sage Creek; but in the form which he has observed from Yellowstone, (Notes on the Later Extinct Floras, &c., pp. 46 to 48,) the leaves are much longer, decurrent, without narrowing at the base, as in the living species of *Sequoia*. If, therefore, this form of decurrent leaves is to be considered as a generic character, his species is a true *Sequoia*. Our leaves, narrowed at base, though evidently slightly decurrent, have the same character, and are besides associated with cones of *Sequoia;* but they are sometimes abruptly pointed and short, like the leaves of what Heer names *Taxites microphyllus*, (Fl. Alas., p. 24, Pl. i, Fig. 9,) or narrower, longer, ensiform, distant, nearly as in *Taxodium Tinajorum*, Heer, Pl. i, Fig. 1, *loc. cit.* All the specimens, representing our species, as described above, are mere small branchlets of annual growth; but as all are bearing leaves, like the branches figured and described from Yellowstone, it is a proof that the leaves were not deciduous, as in *Taxodium*. I think, therefore, that this character of decurrent leaves is rightly considered as generic, and distinctly separates the fragments of *Sequoia;* but that the form, length, &c., of the leaves are, as yet, unreliable for specific distinction.

QUERCUS ILICOIDES, (?) Heer, (Fl. Ter. Helv., II, p. 55, Pl. cli, Fig. 25.) The specimens represent three broken leaves of the same species, which only differ from each other by their width and the size of the marginal divisions. The largest is an exact representative of Heer's figure, *loc. cit.* The borders are deeply, pinnately lobed, with sharp pointed lobes, separated by round sinuses. In the other fragments, which are much narrower, the lobes are less marked and the borders become merely wavy, with sharp but short teeth. The nervation is obsolete, the secondary veins being slender and scarcely discernible. They appear to pass obliquely to the point of the lobes, sinuous, and connected to shorter, intermediate veins. The leaves are bordered by a narrow, flattened, cartilaginous (?) margin, as the leaves of species of *Ilex*. By this character, as by their form, these fragments might be considered as representing a species of this genus, resembling especially *Ilex Studeri*, Heer, (*loc. cit.*, III, p. 72, Pl. 122, Fig. 11;) but their nervation is that of a *Quercus*.

14. EVANSTON, UTAH, (BELOW THE COAL.)

Reddish, ferruginous, hard shale, breaking in the line of stratification, containing abundant remains of plants, generally flattened leaves, with surface blackened by a thin coat of coaly matter; details of nervation distinct.

CYPERUS CHAVANENSIS, (?) Heer, (Fl. Ter. Helv., Pl. xxviii, Fig. 1.) A flattened stem, 1 centimeter broad, without any articulation, smooth or obscurely striate, with primary veins thick, varying in distance and separated by very thin secondary veins, as in Fig. 1 F, *loc. cit.*, is referable to this species.

POPULUS OVALIS, (?) Göpp., (Schossnitz, Fl., p. 23, Pl. xvi, Fig. 1.) A fragment, only the middle part of a leaf, with crenate borders, and nervation of this species, or of *Populus eximia*, of the same author, *loc. cit.*, Fig. 2.

POPULUS MUTABILIS var. REPANDO-CRENATA, Heer. Agrees in every point, form of leaf, nervation, &c., with Heer's Fl. Ter. Helv., Pl. lxii, Figs. 5 and 6.

POPULUS ZADDACHI, (?) Heer. Apparently a small form of this species, at least referable to it by the nervation; the borders of the leaf being destroyed. The nervation is like that of the leaf, Pl. v, Fig. 4, of Heer's Baltic Flora.

ALNUS KEFERSTEINII, Göpp. There is a large number of specimens of this species, with the leaves of the same characters as those figured by Heer in Fl. Alas., Pl. 3, Figs. 7 and 8, and also in Fl. Arc., I, Pl. xxv, Fig. 9. Some of the specimens have remains of small seeds and of scales resembling those of this species.

CORYLUS MCQUARRYI, Heer, (Fl. Arc., I, p. 104.) The author has given numerous figures of this variable species. Two forms are especially marked, one with large leaves, having a deeply cordate base, and more distant secondary veins; the other with smaller leaves, rounded, slightly cordate at base, and more closely approached secondary veins. Both these forms, and their intermediate, as figured in Fl. Alas., Tab. iv, are represented by our specimens.

QUERCUS NEGUNDOIDES, *sp. nov.* Leaf thick, about two inches long, cordate at base, enlarged upward to the three-fourths of its length, where it is palmately cleft in three lobes, the two lateral shorter and obtuse, the medial longer and pointed; borders undulate crenate; petiole half an inch long; medial nerve narrow; secondary veins, about five pairs; angle of divergence, 35°; the lowest pair not as thick, and slightly more arched than the upper ones; all craspedodrome, and nearly opposite; a remarkable form, differing from all the species of oak known to me, by its palmately cleft leaves. It is distantly related to *Quercus triangularis*, Göpp., (Schossnitz, Fl., p. 15, Pl. vi, Figs. 13–17,) and somewhat resembling a *Negundo* by the form of the leaves and nervation.

QUERCUS DRYMEJA, Ung., var. (?) Leaves linear-lanceolate, gradually narrowed to the petiole; medial nerve broad and flat; secondary veins in an open angle, more open toward the base, curving along the entire merely undulate borders. We have two specimens of this form, one representing a whole coriaceous leaf, two inches long, half an inch broad, tapering upward into a long point, with a petiole half an inch long. All the leaves referred to this species by the author in his Chloris, and by Heer, also, in Fl. Ter. Helv., have the borders regularly dentate. Even this character is considered by Unger as an essential one of his species. Our leaves, on the contrary, have entire borders, and secondary veins more open, as in *Quercus Neriifolia*, Heer. I am, therefore, in doubt if this form is a mere variety of Unger's species, though Heer, in Fl. Arc., Pl. xi, Fig. 3, has, from Greenland, a leaf with more open veins and undulate or scarcely dentate borders, which he considers as a variety of *Q. Drymeja;* and Gaudin, in 2 Mem., Fl. Foss. Ital., describes and figures numerous leaves of this *Quercus* to characterize his multiple varieties, one of which, *Q. Drymeja* var. *integra*, (*loc. cit.*, Pl. iv, Fig. 22,) exactly agrees in form and nervation with our leaves.

FAGUS DEUCALIONIS, Ung. The same form is figured in Heer's Fl. Arc., Pl. x, Fig. 6, and Pl. xlvi, Fig. 4, with this difference only, that one of the secondary veins of our leaf bears two small tertiary branches,

like *Fagus Castaneæfolia*, or *Fagus Atlantica*, Ung. This casual deviation of simple nervation is often marked in species of this genus, and our leaf, having the borders entire except in the upper part, where they are merely undulate, or scarcely toothed, is referable to this species. The secondary veins are more distant than in any other fossil species of this genus.

BETULA (!) CAUDATA, (?) Göpp. Two fragments of large leaves of this genus, whose upper part only is preserved. Their form is ovate-lanceolate, long pointed, of the same size and of the same nervation as the leaf represented under this name in Göpp., Schossnitz, Fl., p. 10, Pl. iii, Fig. 5. But the exact form of the teeth of the borders is not well recognizable, and therefore the identity of our leaves with the European species is not ascertainable.

BETULA STEVENSONII, *sp. nov.* Leaves small, no more than 2 inches long, ovate or broadly ovate, tapering to a short point, rounded cordate at base, with borders abruptly curved downward to the short (1 centimeter long) petiole, distantly and simply dentate from near the base to the point; medial nerve distinct and narrow; secondary veins opposite or alternate, five to seven pairs, (angle of divergence, 40° to 50°,) passing like their branches to the point of the teeth; veinlets well marked, perpendicular to the secondary veins. A true *Betula*, represented by many specimens, and differing from all the known fossil species by its abruptly rounded base. The secondary veins are not as straight as in our living American species, from which it differs also by the simply toothed or serrate borders. Related to *Betula primæva*, Web., (Pal., vol. 4, p. 21, Pl. v, Figs. 4 and 5.)

ANDROMEDA GRAYANA, Heer. Our specimens represent this species with the borders slightly more curved outward in reaching the petiole, which is a little shorter. The essential nervation is the same, the areolation obsolete. One of our specimens bears a branch with buds, just like the one figured by Heer in his Foss. Fl. of Vancouver Island, Pl. 1, Fig. 9 *b*.

DIOSPIROS LANCIFOLIA, Lsqx. Numerous leaves, varying in width from 1 to 1½ inches, proportionally long, lanceolate-pointed, tapering downward to the petiole. The substance of the leaves, transformed in a pellicle of coal, is thick or coriaceous, nervation distinct, secondary veins running along the borders, as marked in the figure given of this species, by Heer, in Fl. Alas., Pl. iii, Fig. 12. The intermediate veinlets are very thin, the areolation still smaller, but of the same type as in the figure *loc. cit.* The size of the leaves is variable, generally smaller than the leaf of this species from Vancouver, even as small as that of leaves of *Andromeda Grayana*, which these diminutive forms resemble.

CORNUS STUDERI, Heer, (Fl. Ter. Helv., III., p. 27, Pl. cv, Figs. 18–21.) A large leaf, of which the base is destroyed, but whose form and peculiar nervation are in concordance with the characters of this species. Our leaf is similar to figure 18 of Heer's, *loc. cit.*

ACER TRILOBATUM, Al. Br. A broken leaf, whose outline is mostly destroyed. The substance of the leaf is thin; the nervation of the same type as in *Acer trilobatum* var. *productum*, Heer; the lateral lobes appear short and obtuse.

RHUS EVANSII, *sp. nov.* Two entire leaves of this species and many fragments. They are related to those of *Rhus Meriani*, Heer, (Fl. Ter. Helv, III., p. 82, Pl. cxxvi, Fig. 5—11,) being, however, shorter and proportionally broader, more distinctly denticulate and short-petioled. The nervation is that of Fig. 7, *loc. cit.*, which represents a leaf with more distinctly serrulate borders. As the leaves of *Rhus Meriani* are

very variable in size and form, the difference remarked in the form of our leaves could scarcely authorize a specific separation but for the short petiole which they bear, a character of rare occurrence in species of this genus.

JUGLANS RHAMNOIDES, *sp. nov.* Leaves oval, tapering nearly equally upward to a point and downward to a short petiole, entire, varying in size. Two leaves preserved in their whole are 4 inches long and 1¾ inches broad. A fragment, with point and base of the leaf broken, is nearly 4 inches broad, with borders apparently rounded toward the base. Veins thin but distinctly marked; secondary veins equally distant and parallel; 10 pairs, oblique 40°, curving from the base in going to the borders, and more still near the borders, which they closely follow in dividing; nervilles distinct, thick, more or less continuous and branching. It is difficult to decide if these leaves of ours are referable to *Juglans* or to *Rhamnus.* Professor Heer, in his Arctic Flora, I, p. 123, Pl. xlix, Fig. 10, has a leaf so much like the best preserved one of Dr. Hayden's specimens that it looks like a copy of it; except, however, that in Heer's figure the secondary veins oblique to the medial nerve, ascend nearly straight to near the borders, where they abruptly curve and divide. The author says that but for the more straight secondary veins his leaf should be considered a *Juglans.* Therefore these curved secondary veins of our species identify it to this genus. But in the leaves which represent it, the secondary veins are closer to each other, more exactly parallel, running also nearer to the borders than in any species of *Juglans;* except, perhaps, *Juglans acuminata,* Al. Br., which, in Fl., Alas.; Pl. ix, Fig. 1, is represented by Heer with leaves of a more regular nervation, and secondary veins going nearer to the borders than in any other figures of this species. This new species is, therefore, closely related to *Juglans acuminata,* Al. Br. As it bears still the same relation to *Juglans rugosa,* Lsqx., and *Cornus acuminata,* Newby, these three species may be mere varieties of that polymorphous *Juglans acuminata* which has been found over the whole extent of the Tertiary formation of both continents as far as they are known.

JUGLANS APPRESSA, Lsqx., (Trans. Am. Phil. Soc., vol. 13, p. 420, Pl. xx, Fig. 6. Undoubtedly the same species represented by two specimens.

CARYA ANTIQUORUM, Newby. (Extinct Fl. N. A., p. 72, Pl. xxiii, Figs. 1 to 4, ined.) Two large leaves referable to this species. There are still in the collection of Dr. Hayden some specimens of leaves of a *Carya,* 6 inches long, 3½ inches broad, broadly ovate-lanceolate, rounded and narrowed downward to a thick, long petiole, with serrulate borders, &c., which differs from the figures and description of the species by a thick medial nerve, by secondary veins much more open near the base, by the borders rounded to the base, and by the broader size of the leaves. The differences may be merely resulting from the position of the leaves, as lateral or terminal leaflets of a compound leaf.

15. EVANSTON, UTAH, (ABOVE COAL.)

Shaly, whitish sandstone, with few remains of leaves; outlines and primary nervation only distinguishable, details of structure obscured by the coarseness of the stone.

CINNAMOMUM SCHEUZERI, Heer. Same form of leaf as the variety figured by the author in Fl. Ter. Helv., Pl. xciii, Fig. 2, with details of nervation as marked Fig. 5 of the same plate.

PLATANUS NOBILIS, Newby. A number of specimens, mere fragments of a very large leaf, with nervation of this species. The leaf is still larger than the beautiful specimen described by Dr. Newberry, *loc. cit.*, p. 66, Pl. xvii, ined.

RHAMNUS RECTINERVIS, Heer, (Fl. Ter. Helv., III, p. 80, Pl. cxxv, Figs. 2–6.) The leaves representing this species are as large, even larger, than the greatest leaf (Fig. 6) figured from European specimens. The secondary veins are nearer to each other, or more numerous, at least 15 pairs in a leaf of the same size as that of Fig. 6. But these differences are of no specific value, fragments of other leaves of the same showing a variable distance between the veins. The borders of the leaves are entire, except near the point, where they are sometimes denticulate. The secondary veins, deeply marked, slightly curved in going out from the medial nerve, ascend straight to the borders in an angle diverging 25° to 30°.

CARPOLITHES LINEATUS, Newby., (Pl. xxv, Fig. 1, ined.) Apparently the same kind of nut, as yet undescribed. All Dr. Hayden's specimens, found in great numbers scattered in the sandstone, are more or less flattened, round-oval in outline, marked with thin *striæ*, but without the point as in the figure *loc. cit.*, which would indicate them as fruits of a *Corylus*. The name of the fruit is therefore preserved; but its relation to species of our present vegetation is as yet unknown. They are apparently referable to palms.

16. DIVIDE BETWEEN THE SOURCE OF SNAKE RIVER AND THE SOUTHERN SHORE OF YELLOWSTONE LAKE.

A grayish, fine-grained, hard shale, breaking in layers, with few remains of plants.

GYMNOGRAMMA HAYDENII, *sp. nov.* A fine fern, with a frond apparently tripinnate; *pinnæ*, long, linear-lanceolate, gradually decreasing to an obtuse point, pinnately divided toward the lower part in alternate linear-lanceolate, obtuse pinnules or lobes, enlarged downward in a broad, decurring base, distantly serrulate, and disconnected nearly to the main *rachis*; toward the upper part of the *pinnæ* the divisions become shorter and broader, about triangular-obtuse in outline, connected from the middle; near the point they are united nearly in their whole length, passing to a terminal, small, obtuse leaflet. The nervation is not quite distinct; medial nerve, thin, well marked in the lower divisions, becoming obsolete in the upper ones; secondary veins very oblique to the medial nerve; the lowest ones coming out from the main *rachis*, at least in the largest decurrent divisions; all dichotomous in ascending. The substance of the leaves is thick, and the veinlets appear to be rendered obsolete by particles of pulverulent matter hardened into coal. By the form of its divisions, this species is related to *Sphenopteris Blomstrandi*, Heer, (Fl. Arc., I, p. 155, Tab. xxix, Fig. 1–5, 9*a*,) from the Miocene of Spitzbergen, differing essentially by its nervation, which is more like that of *Gymnogramma tartarea*, Desv. Even in the mode of division and the form of the lobes, this last species, especially in specimens obtained from cultivation, resembles the fossil plant. The small, badly preserved fragments obtained from near Gold City, and considered with doubt as a *Lathræa* in Am. Jour. Sci., March, 1868, p. 207, is probably referable to this species.

SABAL MAJOR, (?) Ung. This specimen has only broken parts of lateral rays and the undistinct point of the *rachis* (?) of a *Sabal*. It represents a large species; may be *Sabal Campbellii*, (?) Newby.

Diospiros stenosepala, Heer, (Fl. Alas., p. 35, Pl. viii, Fig. 8.) One leaf only, with the point destroyed as in the specimen from Alaska, but satisfactorily identified by its form and peculiar nervation. The medial nerve is broad and grooved, the secondary veins, with angle of divergence 50°, curve from the middle upward and along the borders with thick tertiary and intermediate fibrillæ. The leaf is shorter and proportionally broader than the leaves of *D. lancifolia.*

Besides the named species, the shales have undeterminable fragments of *Populus, Rhamnus, Juglans,* &c.

17. Mouth of Warm Spring Cañon.

Fine-grained, gray sandstone, hardened by metamorphism; only two specimens, representing one species.

Quercus Gaudini, Lsqx., (Am. Jour. Sci., May, 1859, p. 360.) Described from an imperfect specimen from Bellingham Bay, and figured by Gaudin (Fl. Ital., 2d Mem., Pl. vi, Fig. 5) from European specimens. Gaudin's species does not appear to agree exactly with the American form, but rather to be a variety of *Quercus Scillana,* Gaud., as he supposes it. The base of our leaf is not rounded, but gradually narrowed; the point is lanceolate or tapering; and the secondary veins, thick at and near the base, and curving, enter the upturned point of the distant small teeth. The affinity of this species is with *Quercus Drymeja,* Ung., as figured in Heer's Fl. Ter. Helv., (Pl. lxxv, Fig. 18.)

18. Six Miles above Spring Cañon and Top of Hills between Fort Ellis and Botteler's Ranch.

Dark-greenish, coarse-grained shale, breaking in every direction, hardened by metamorphism.

Phragmites Alaskana, Heer, (Fl. Alas., p. 24, Pl. v, Fig. 12 and 12 *b.*) Two specimens, agreeing in every point with the author's description and figure. The distance between the longitudinal veins is 1 millimeter, with intermediate veinlets, extremely thin and somewhat obsolete; the size of the leaves is also the same. Professor Heer supposes that this form may be a variety of *Phragmites Oeningensis.* The discovery in our American western Tertiary formations of remains of exactly the same characters as those which separate this form is proof of its specific value.

Populus leucophylla, Ung. The specimens represent this species in various of its forms as figured in Gaud., Fl. Ital., 1st Mem., p. 29, Pl. 4, Fig. 1–5. It appears of common occurrence in our Tertiary strata. Heer has published it from Alaska, and Dr. Newberry's *Populus acerifolia* (Am. Lyc. Nat. Hist. of New York, vol. 18, p. 65, Pl. xiii, Fig. 5–8, ined.) is referable to it.

Populus mutabilis var. lancifolia, Heer. Two entire small leaves, the largest one 2½ inches long, ovate-lanceolate, obtuse, thick, coriaceous, with distinct nervation of the species; the other scarcely half as long, nearly oval, with undulate borders and undistinct nervation. These leaves are more obtuse than any of the numerous forms figured by Heer of this polymorphous species; but there is no other difference.

Salix Grœnlandica, Heer, (Fl. Arc., I, p. 101, Pl. 4, Fig. 10.) Two specimens representing only the lower half of a leaf, agreeing with the description and figure of this species. The leaf appears of a thick

texture, and the nervilles are not distinct as in the specimen from Greenland. This is probably the result of the coarseness of the stone. One of the specimens bears two fragments of leaves of this species, one of which has the secondary veins more distant, as in *S. Grœnlandica*, while the other has them much more approached to each other, just as they are in *Salix Rheana*, Heer, figured on the same plate, Fig. 12, with nervilles discernible. I consider both species as identical.

MYRICA AMBIGUA, *sp. nov.* A species represented by three incomplete specimens. Leaf apparently long, (point broken,) linear-lanceolate, narrowed to the base, in an outward curved line, about 2 inches broad, or less, the other specimens being narrower, with borders distantly and obtusely serrulate; medial nerve, broad, narrowly furrowed; secondary veins in right angle to the medial one, thick at the base, much thinner in the middle, where they branch, anastomosing with divisions of the upper and lower veins, and also with shorter intermediate ones, which separate them. Nearer to the borders the nervation becomes indistinct. It is distantly related to *Myrica Banksiæfolia*, Ung., as figured Fl. Alas., Pl. ii, Fig. 11.

CORYLUS MCQUARRYI, Heer. Mixed with fragments of *Populus leucophylla*, Ung.

QUERCUS ELLISIANA, *sp. nov.* Leaves ovate-lanceolate, pointed, or obtusely pointed; round cuneate at base, with borders marked with short, distant angular teeth becoming obtuse toward the point; medial nerve deeply marked; secondary veins, eight to ten pairs, emerging at an open angle, 55°, curving in ascending to the borders and entering the teeth, The lowest pair branch once or twice downward; the second pair has sometimes one inferior branch near its point; all the other veins are simple; nervilles, undistinct, crossing the veins at right angles. This species is allied to *Quercus Pseudo-alnus*, Etting., (Bil., Fl.,) which has more deeply marked and more acute teeth, with secondary veins at a more acute angle of divergence and more distant.

QUERCUS PEALEI, *sp. nov.* A small coriaceous, short, petioled leaf, 1½ inches long, ovate in outline, cuneate and entire to the petiole, more abruptly narrowed from above the middle into an obtuse point, and there obtusely and distantly crenate; medial nerve deeply marked, like the secondary veins; four to five pairs in acute angle, (30°,) curving in going to the borders, where they enter the teeth, except the lowest pair, which curves upward, follows the borders, and unites by ramification with branches of the second pair. It is a fine species, somewhat like *Quercus fagifolia*, Göpp., (Schossnitz, Fl., p. 14, Pl. vi, especially Fig. 9,) from which it differs by the cuneate rounded base of the leaves, the more deeply marked teeth, and more curved secondary veins.

QUERCUS GODETI, Heer. Two specimens of leaves, with all the characters of this species, as described by Heer, (Fl. Ter. Helv., II, p. 50,) especially resembling Pl. cli, Fig. II. The borders of the leaves appear only irregularly serrulate, and not doubly so, as marked in the figure; but the coarseness of the stone obliterates the details. By the borders, unequal at the base, and by the nervation, these leaves, like those of Europe, seem referable to *Juglans*. The areolation is undistinct.

QUERCUS LAHARPI, Gaud., (Fl. Ital., 2 Mem., Pl. iii, Fig. 5, 10.) The leaves referable to this species differ only from it by their smooth surface, and the secondary veins, more numerous, sixteen pairs at least, nearer to each other, and more curved in passing out to the borders. According to the author the surface of the leaves of his species is

rugose, which is not the case in ours. However, Professor Heer has in his Arctic Flora figured this species, (II, p. 472, Pl. xlix, Fig. 2–4,) without mentioning the rugosity of surface, and with form of leaves, dentation, and nervation of exactly the same characters as in our specimens. It is very probably the same.

FICUS TILIÆFOLIA, Al. Br. Obscure fragments.

SASSAFRAS, species. Represented only by a single specimen of the lower part of a leaf. The lateral veins branch at a distance from their base, and there is no trace of tertiary nervation or areolation. These are mere negative characters, and the only ones agreeing with those of *Sassafras Ferretianum*, Mass., a species which is restored by Heer, from fragments of Greenland, in Fl. Arc., II, p. 474, Pl. l, Fig. 2. Ours differs by the borders and the lateral veins diverging from the petiole and from the medial nerve in an angle of 60°, doubly as broad as the angle of divergence in the species from Greenland. I have no access to Massalongo's description and figure of his species, but from Gaudin, who has the same species published in Fl. Ital., II, p. 50, Pl. 10, Fig. 8, ours is far different, especially by the total absence of secondary, horizontal veins, lower than the fork of the primary veins, and also of the reticulation, generally so well marked in leaves of this genus.

CINNAMOMUM SCHEUZERI, Heer, (Fl. Ter. Helv., p. 85.) This species is represented in its various forms by a number of specimens, even in its marked variety figured *loc. cit.*, Pl. xciii, Fig. 2, 3, 4.

ANDROMEDA GRAYANA, Heer, (Vancouver Fl., p. 7, Pl. i, Fig. 7–9.) The same can be said of this species as of the former. It is represented in the specimens by such a large number of fragments of its various parts and of various sizes that it is not possible to doubt identity. Some of our fragments are still larger than Fig. 9, *loc. cit.*

ANDROMEDA RETICULATA, (?) Etting., (in Heer, Balt. Fl., p. 36, Pl. xxvi, Fig. 5–9.) Two lanceolate leaves of thick, leathery texture, tapering to the petiole, with a broad, half-round medial nerve, and obsolete, secondary veins at an acute angle, like those of *A. Grayana*, curving along the borders. The undistinct reticulation appears to be as figured by Heer; but this appearance may be due to the coarseness of the stone. By their form and the direction of the secondary veins the leaves resemble *A. Grayana*, differing, however, evidently by the thickness of the medial nerve. Both these leaves are larger than those figured in the Baltic Flora, being about 3 millimeters broader.

JUGLANS RUGOSA, (?) Lsqx.; CORNUS ACUMINATA, (?) Newby. The same remark is applied to this leaf as in p. 294 to *Juglan's Rhamnoides*.

LYRIODENDRON, species. Also represented by one fragment, the lower half of a leaf. The base is at first obliquely descending to the petiole, and then, curving abruptly downward, becomes decurrent upon it in a short border; leaf of thick texture, with broad medial nerve; secondary veins and nervilles strongly marked. In his Fl. Arc., Professor Heer has figured, without description and specification, (I, Pl. xxvi, Fig. 7 *b*,) from Iceland, part of a leaf of *Lyriodendron*, of same size, differing only from ours by the not decurrent base.

RHAMNUS RECTINERVIS, Heer. A single specimen of a whole leaf. No difference. See above (p. 295) remarks on the same species.

JUGLANS DENTICULATA, Heer. (Fl. Arc., II, p. 483, Pl. lvi, Figs. 6–9.) Leaves lanceolate rounded to the petiole (broken,) with undulate borders, denticulate near the point; secondary veins much curved, especially toward the base of the leaf, the end running close to the borders, numerous, 12 pairs or more. Except that this leaf is narrower, nearly linear, or with borders parallel in the middle, it does not differ from the Greenland form.

19. From High Ridge, about Ten Miles West of Hot Springs.

Hard, yellow, metamorphic shale, fine-grained, and hard as silex; has only fragments of *Cinnamomum Scheuzeri*, Heer; and *Ficus tiliæfolia*, Al. Br.

20. Near Yellowstone Lake, among Basaltic Rocks.

Same kind of stone as the former, and harder, if possible.

Rhamnus rectinervis, Heer. Many specimens, some of which, on account of their slightly more curved secondary veins and entire borders at and near the point, might be referable to *Rhamnus Eridani*, Heer, as figured in Fl. Arc., Pl. xix, Fig. 7*a*. In our specimens, however, the veins are more curved along the borders.

Ficus tiliæfolia, Al. Br. The mere skeleton of a leaf, the primary nerves only being preserved.

Populus Balsamoides, (?) Göpp. A fragment, the upper part of a leaf which appears to complete the figure in Heer's Fl. Alas., Pl. ii, Fig. 3.

Equisetum limosum, Lin. Stem narrow, 4 millimeters broad, undulately 10-ribbed, marked with sheathed articulations 10 millimeters distant; sheaths short, brown-colored, fringed with lanceolate acute points. The color of the sheaths may depend from the presence of oxide of iron. It is, however, remarkable that all the sheaths and these parts of the plant only have the same color as in *E. limosum* of our time. The form of the divisions of the sheaths and their length are not quite distinct, but appear as in the living species, short, rigid, appressed, acute, brown teeth. I consider it as identical.

Fragments of *Cyperites*, analogous to *Cyperus angustior*, Heer.

21. Three Miles above Spring Cañon.

A kind of very hard, metamorphic, shaly limestone, with numerous broken and badly preserved fragments of plants, a few of which are recognizable.

Sequoia Reichenbachi, (?) Heer, (Fl. Arc., I, p. 83, Pl. xliii, Figs. 1*d*, 2*b*, 5*a*.) Branches and branchlets bearing linear-lanceolate, narrow long leaves, sharply pointed, decurring upon the branches by an enlarged base, marked by a medial nerve, open at first, but turning upward near the point, or falcately curved. Upon young branchlets the leaves are merely oblique and straight. Upon larger branches they are open and curved, only seen at intervals, the space between them being marked by broad, obovate, abruptly pointed, and nerved scars of scales or leaves. There is no trace of cone or of any other remains referable to conifers. It much resembles *S. Reichenbachi*, Heer, *loc. cit.*, differing, however, by its diminutive size, the leaves, branches, and scales being at least twice narrower than in the specimens figured by Heer from the Cretaceous formation of Kome, Greenland. It bears to *S. Reichenbachi* the same relation as *Glyptostrobus gracillimus*, Lsqx., of the Cretaceous of Nebraska, bears to *G. Europeus* of the Miocene.

Phyllocladus subintegrifolius, Lsqx., (Am. Jour. Sci., vol. XLV, p. 92, Pl. iv, Fig. 8, ined.) The nervation of this species is so peculiar that the identification of its different forms is certain. The leaf has the point broken; its form is oval-oblong, with the borders entire from the base to above the middle, where they become marked by distant, obtuse, short teeth. The medial nerve is only marked at the base by a

short swelling. The veins are very close to each other, closer than in any species of fern, dichotomous in ascending from the medial nerve in a very acute angle, their base being parallel to it before joining it.

ANDROMEDA PARLATORII, Heer, (Phill. Cret. du Nebraska, p. 18, Pl. i, Fig. 5.) Neither in this work nor in my addition to the Fossil Plants of the Mississippi, *loc. cit.*, has this species been figured in its whole or with the point and the petiole. One specimen has an entire leaf. It is narrowly lanceolate, gradually tapering to a long, acute, slightly scythe-shaped point, and also gradually tapering downward to a short, broad, slightly winged petiole. The nervation is as figured by Heer; the secondary veins emerging in an acute angle, thick, curving upward, evanescing near the borders.

MAGNOLIA ALTERNANS, Heer. The upper half of a leaf about the same part with same nervation as Heer's Fig. 3, of Pl. iii, in Phyllites du Nebraska. Apparently identical; nervation obsolete.

22. HARD, SHALY, FINE-GRAINED, WHITISH SANDSTONE.

About of the same consistence and color as the specimens from Carbon Station. The precise locality is unknown, the labels having been lost or forgotten. This is regrettable, on account of the peculiar character of the remains of plants, mostly leaves of *Ficus*, which are preserved in these shales.

CYPERUS CHAVANESIS, Heer. Many specimens representing leaves of various size, as those of Fl. Ter. Helv., I, Pl. xxviii, Fig. 1*a*, with cross-lines perpendicular to the nervation, as in Fig. 1*d*, and with a stem with broad *striæ* of different color, as in Fig. 1 *f*, of the same plate. Some of the leaves have numerous marks of a small fungus, *S. clerotium*, which is like *S. pustuliferum*, Heer, (Fl. Ter. Helv., I, p. 21, Pl. ii, Fig. 12 and 12*b*.)

POPULUS ARCTICA, Heer. It is the same form as that of Pl. v, Fig. 3, of Fl. Arc., represented by two specimens.

FICUS MULTINERVIS, Heer, (Fl. Ter. Helv., II, p. 63.) With the form of leaves as in Pl. lxxxi, Fig. 9, and secondary veins still more numerous and also slightly more oblique than in Fig. 6 of the same plate. It cannot be separated from this species.

FICUS LANCEOLATA, Heer, (*loc. cit.*, p. 62.) One large specimen is covered with numerous leaves of the same character as those figured in Fl. Ter. Helv., Fig. 13, Pl. clii. They much differ in appearance from the following form, also represented by numerous leaves.

FICUS ARENACEA, *sp. nov.* Differs from the former species by broader leaves of a thicker texture, not tapering, but somewhat rounded to the petiole, by the medial nerve, twice as broad and grooved near the base. The secondary veins are strong, but the ultimate reticulation is obsolete.

FICUS GAUDINI, *sp. nov.* A fine species, with broadly ovate-lanceolate pointed leaves, (the point is destroyed,) rounded at the base to a short, thick, curved petiole, varying in length from 3 to 7 inches, and proportionally broad, from $1\frac{1}{2}$ to $3\frac{1}{2}$ inches; medial nerve thick and broad, grooved from the middle to the petiole; secondary veins nearly at a right angle to the medial nerve, slightly more oblique in ascending to near the point where the angle of divergence is still 60°, abruptly curving at a distance from the borders. The base of the leaves is about as in the living species *Ficus Americana*, Auct.; but no fossil species of this section is comparable to it. The presence of so many leaves, types of the section of a genus, forces the question of possible identity of those different forms, distinct and separable by what appears good specific charac-

ters, and the question becomes still more pressing when the examination of paleontologists bears upon remains of a genus which indicates for each species in the living state the greatest diversity in the forms, even in the nervation of its leaves. I will not repeat what I have said formerly* concerning the specification of vegetable fossil remains, but merely remark that we have to deal with characters which, though unreliable, must be admitted and described according to the general rules of scientific descriptions, and cannot for each of these characters take into account the possibilities of variations, except when they are in some way indicated by intermediate forms. In this particular case, it is right to say: that the leaves representing the different species above named are grouped upon different specimens, each group presenting the same characters; and that these characters do not show any transitional form from one species to the other.

PLATANUS, undeterminable species. In fragments. One of the specimens bears large pieces of bark with exuded matter, like glomerules of amber.

CINNAMOMUM, (!) species. Broken fragments of large leaves, broadly oval and rounded at the base, lanceolate to a point, (?) (broken;) texture of the leaves thin or not coriaceous; lateral veins slightly curved in ascending to three-fourths of the leaves, moderately branching outside; medial nerve pinnately branching from the middle upward. This species appears related to *Cinnamomum Heerii*, Lsqx., of the Mississippi Tertiary, and also to the large forms of *Cinnamomum polymorphum*, Heer.

23. CRETACEOUS STRATA, KANSAS.

Specimens communicated by Professor B. F. Mudge, on hard, ferruginous sandstone.

Remark.—As the following species have been figured for a detailed report of the fossil plants obtained from the explorations of Dr. F. V. Hayden, a short description of them finds its place in this paper, though the specimens have been collected by Professor B. F. Mudge, of Manhattan College, Kansas, and kindly sent for examination. These specimens are, indeed, beautiful, representing whole leaves, fully preserved in their outline and in the details of their nervation. They add to our knowledge of the extinct floras a number of remarkable forms, interesting to paleontologists, not only by their characters, but especially as affording new data for the study of the species and of the distribution of the Cretaceous flora on both continents.

PTEROSPERMITES QUADRATUS, *sp. nov.* A large leaf, round, quadrate in outline, 5 to 9 inches both ways, with entire, more or less wavy borders, round truncate to the base, obtusely short-pointed; medial nerve round and thick, overlapped at its base by the borders of the leaves, passing it by about half an inch; inferior secondary veins, narrow, somewhat flabellate around the base of the medial nerve, or diverging in right angles from it; first pair of opposite secondary veins, half an inch above the base of the medial nerve, strong, diverging at an open angle, much branching downward; nervilles deeply marked, becoming thicker in contact to the secondary veins, nearly continuous; substance of the leaves, coriaceous. From the first pair of opposite secondary veins, the others, in ascending, are nearly parallel, equidistant, passing obliquely to the borders, scarcely curved, craspedodrome, as in all the species of this genus. By its nervation this species is related to *P. dentatus*, Heer, (Fl. Arc., I, p. 138, Pl. 23, Fig. 6.)

* American Journal of Science and Arts, vol. xlv, p. 103, note.

PTEROSPERMITES MULTINERVIS, *sp. nov.* The outline of the leaf is destroyed. From the direction of the veins, it appears to have about the same form as the former species, from which it differs, especially by its numerous basilar veins, eight of which are visible, diverging fan-like from the base of the medial nerve, and by the much more numerous secondary veins, twelve pairs being counted in the leaves of this species, while the former has only seven to eight pairs, with larger leaves. In this species, also, the nervilles are deeper, less divided, and continuous.

PTEROSPERMITES HAYDENII, *sp. nov.* A small leaf, 3 inches long, 2 inches wide, ovate-lanceolate, obtusely pointed, rounded to the petiole, (broken,) with borders, not overlapping at base, deeply undulate or irregularly, obtusely short-lobed from below the middle to the point; medial nerve deep and narrow; three pairs of thinner, inferior, lateral, secondary veins, diverging nearly in right angles from the medial nerve; the fourth pair stronger, more oblique, more or less branching, ascending straight to the point of a lobe like the others, five pairs above it; nervilles deep, continuous, connected in the middle by cross-branches. A fine leaf, allied to *P. spectabilis*, Heer, of North Greenland, in Fl. Arc., II, p. 480, Pl. xliii, Fig. 15.)

MAGNOLIA ENSIFOLIA, *sp. nov.* Represented by two leaves, one 3 inches long, 1 inch wide; the other 6 inches long, 2½ inches broad; linear, abruptly cuneate to the base or petiole, (not seen,) and also abruptly round-pointed at the top; borders, entire or slightly wavy; medial nerve, broad, flat; secondary veins, oblique, diverging 40° to 50°, curving from the middle upward, and branching twice or more in anastomosing with branches of the nearest veins. The leaves are of thick, coriaceous texture, having the same nervation and areolation as our *Magnolia grandiflora*, L. It is related to *Magnolia crassifolia*, Göpp., (*Beytraege zur Ter. Fl. Schlesiens*, Tab. iv, Fig. 1 and 2.)

QUERCUS MUDGII, *sp. nov.* An oval lanceolate leaf, (point broken,) either narrowed to the base or somewhat enlarged and abruptly rounded-truncate to the petiole; medial nerve twice as broad as the secondary veins, 8 to 10 pairs, which are alternate or opposite, oblique, (40°,) straight or slightly flexuous in passing to the borders, branching once or twice, and entering, with each of their divisions, the point of a short tooth; the borders being regularly marked by short, equal teeth separated by obtuse sinuses. Closely allied to the leaf, published by Dunker as *Castanea Hausmanni, in Pflanzenreste aus dem Quadersandstein von Blankenburg*, Pal. Vol. IV, p. 179, Pl. xxxiv, Fig. 1, at least for the nervation and the dentation of the borders.

ARALIA (?) QUINQUEPARTITA, *sp. nov.* Under the name of *Aralia formosa*, Professor Heer has published, in Flora Cret. von Moletin, p. 18, Pl. viii, Fig. 3, a trilobate leaf, serrulate on the borders, to which ours is closely allied. This merely differs by a division of the lateral lobes from the middle, thus forming a quinque-partite leaf, and by the borders which are entire, at least as far up as they are preserved, the upper part being destroyed. It is a coriaceous leaf with three broad, flat, secondary veins, diverging, a little above the base of the leaf, from the enlarged medial nerve. The lateral veins divide still from below the middle, forming on both sides two new divisions of the leaf, which, as said above, becomes quinque-partite. I do not know any living species of *Aralia* to which this leaf may be compared.

PLATANUS NEWBERRYANA, Heer, (Phill. Cretac., p. 16, Pl. i, Fig. 4.) A fine and more complete specimen of this species is preserved in the Museum of Comparative Anatomy of Cambridge, from the collection of fossil plants of Professor Marcou. It shows a rhomboidal leaf, enlarged

in the middle into a short lobe, narrowed upward to an obtuse point, cuneate to the base, with borders undulately denticulate; secondary veins, oblique, straight, the lower pair ascending to the point of the lobes, much divided; nervilles, simple, continuous, deeply marked.

PLATANUS HEERII, *sp. nov.* A species represented by many good specimens. Leaves, round in outline, with short, obtuse, lateral lobes, and an obtuse, short point; borders entire, wavy, or obtusely, distantly dentate, passing in a broad angle, even by a rounded curve toward the petiole, on which they descend in decurring to it, forming a short wing. Petiole apparently short, one inch long, as seen in one of the specimens. The basilar wing is marked with one or two pairs of horizontal, narrow veinlets, running along the borders; the first pair of secondary veins above them is thick, straight, oblique, much divided in tertiary and quaternary veinlets, which, like the febrilles, are deeply marked. Texture, thick; surface, smooth; areolation of *P. occidentalis.* As in this species also, the second pair of lateral veins is at a greater distance from the first.

SASSAFRAS OBTUSUS, *sp. nov.* A true sassafras, to which is referable the leaf published in Am. Jour. Sci., vol. XLV, p. 94, under the name of *Populites Salisburiæfolia*, Lsqx.

PHYLLOCLADUS SUBINTEGRIFOLIUS, Lsqx., (*loc. cit.*, p. 92.) A larger leaf than the former described ones, obovate, undulate on the borders from the middle upward, obtusely pointed, with same nervation.

II.—REMARKS ON THE CRETACEOUS SPECIES DESCRIBED ABOVE.

The above enumeration mentions fourteen species of fossil plants from our Cretaceous formations. It is a small group, indeed; yet, on the whole, an interesting and valuable contribution to our knowledge of the Cretaceous flora of our continent. Seven of these species are new; three *Pterospermites*, the first American representatives of this group, excepting, perhaps, one species of the genus *Credneria*, considered by some authors as allied to it, though not yet satisfactorily determined.* The *Pterospermites* re-appear in the Tertiary of our continent, with analogous characters, at least. *P. quadratus*, Lsqx., resembles, especially by its nervation, *P. dentatus*, Heer, from Mackenzie, while *P. Haydeni*, Lsqx., is, by its size, the form of its leaves, and their nervation, a near relative of *P. spectabilis*, Heer, from Greenland. The affinity of typical forms is remarkable, on account of the difference of latitude or of the geographical habitat and the geological station of these plants. The fourth new species, *Magnolia ensifolia*, Lsqx., is allied by some characters to *Magnolia crassifolia*, Göpp., from the Tertiary of Silesia; while the fifth, the fine *Platanus Heerii*, Lsqx., has, for representative in our Tertiary, *Platanus aceroides*, Göpp., and *Platanus Guillelmæ*, Göpp., two intimately related forms. Therefore, on seven new species of the Cretaceous described here, five have a marked Tertiary facies, while, at the same time, three of them, at least, have what may be called an

* Our *Pterospermites* have analogy of form and nervation with *Pterospermum*, Schreb., a genus of the *Buttneriaceæ*. Heer, in his Fl. Ter. Helv., has published seeds referable to the same kind of plants. There is, therefore, scarcely any doubt about the relation of these leaves. It is different with *Credneria*. Its place is, as yet, undefined. Though resembling by some of its characters, especially by size and general nervation, the leaves of some *Pterospermites*, their form, their basilar nervation, and the mode of attachment of the petiole are different. We have from our Cretaceous of Nebraska one *Credneria*, (*C. Le conteana*, Lsqx.,) apparently identical with *C. macrophylla*, Heer, of the Quadersandstein or Upper Cretaceous of Moletein, Moravia.

Arctic facies. The two other species have, as yet, relation only with other plants from the Quadersandstein of Europe. *Aralia quinquepartita*, Lsqx., is a relative of *A. formosa*, Heer, from Moletein. The author compares it to *A. primigenia*, from Mount Bolca, a locality well known by its fossil flora, which, though referred to the Eocene, has some typical Cretaceous forms. *Quercus Mudgii*, Lsqx., as remarked in its description, is comparable to *Castanea Hausmanni*, published by Dunker, from the same formation (Quadersandstein) of Blankenburg.

Do the four species which have been described, from the locality three miles above Spring Cañon, bear an evident Cretaceous facies? This locality is in the neighborhood of strata bearing remains of Tertiary plants, and this inquiry is forced by the presence of Cretaceous types at a station where they were unlooked for. The first of these species, referred to *Sequoia Reichenbachi*, Heer, from the Cretaceous of Cone, Greenland, is identical in characters, except in the diminutive size of the form represented by our specimens. This difference in the size of branches and leaves of conifers cannot be considered as specific, especially for plants of a same geological formation. The second form, referred to *Andromeda Parlatori*, Heer, from the Cretaceous of Nebraska, is represented by an entire leaf, better preserved than any specimen as yet obtained of it, and, therefore, I consider its identification as certain. The third, *Magnolia alternans*, Heer, also formerly obtained from Nebraska, is a mere fragment, and on that account its identity might be disputed. The fourth, *Phyllocladus subintegrifolius*, has not yet any relative in the Tertiary formations; and, therefore, even omitting the third species as doubtful, we have still three distinct Cretaceous forms, affording evidence to the age of the strata where they have been found. According to the indications kindly furnished by Dr. Hayden, these strata are either in the lowest part of the Tertiary strata of the West or in the upper part of the Cretaceous, there being still a great thickness of measures between the Kansas or Nebraska leaf-bearing Cretaceous strata and those of Spring Cañon. It seems, therefore, that we may come to the conclusion: first, that there is still a succession of vegetable representatives of our Cretaceous flora, ascending much higher in these measures than at the localities where the first remains of this flora were obtained; secondly, that if it is the case, we may expect to find in those intermediate strata representatives of transitional forms from our Cretaceous species to those which have been found and described from the so-called disputed strata, necessarily considered, from the characters of their vegetable remains, as of Tertiary age. The examination of the intermediate measures is, therefore, of great interest, as from the modifications of typical forms in these measures, supposed successive in time, we may find facts proving a series of changes, or of specific forms, under appreciable influences.

III.—TERTIARY FLORA OF NORTH AMERICA.

§1. General Remarks.

In the introduction of a pamphlet recently published by Professor Heer, "On some Fossil Plants of Vancouver and British Columbia," the author remarks that "while we are now acquainted with a large number of species of fossil plants from the Miocene of Europe, we know scarcely any from the same formation of America. And yet this knowledge would be most valuable to science, as it would give us, on the history of the vegetable world, on the origin and succession of vegetable types, on the relation of the Tertiary flora of America with

that of Europe, and consequently with the climatic conditions of both countries, the most important information." From these considerations my celebrated friend infers that his descriptions of seven Tertiary species of fossil plants from Vancouver Island and British Columbia, must be considered a valuable contribution to vegetable paleontology. If this is right, and no naturalist of conscience will deny the truth of the above conclusions, how high shall we estimate the result of the researches of Dr. F. V. Hayden, who, in his last tour of geological explorations, has obtained from twenty different localities of the Western States or Territories many hundred specimens, representing more than eighty species of Tertiary fossil plants? The importance of these researches, to which we are indebted, also, for most of what we know of the vegetation of our Cretaceous formations, has been already acknowledged by science here, and especially in Europe, as evinced by the notable discussions which they have provoked. As it may be seen by the map of the Yellowstone and Missouri Rivers, and their tributaries, in Dr. Hayden's report, (1870,) the area occupied in the West by Tertiary formations is of considerable extent. Already the fossil plants known from this formation represent localities from Nebraska, Dakota, Montana, Utah, Wyoming, &c. We may thus already foresee that in a not far distant time the fossil flora of the recent formations of our continent will have been studied and be known well enough to draw to it a more general interest; for then it will be able to answer most of the questions which now occupy the mind of the paleontologists, and which, as already remarked, bear upon some of the most interesting problems of the history of our earth's surface.

§ 2. Table of Distribution of Species.

The following comparative table of distribution of our Tertiary fossil plants indicates the relation of species to localities and to the different stages of the Tertiary formations both in Europe and in America, by reference to identical or analogous species. To render the table more complete, more interesting for the present, and at the same time more useful for the future as a kind of frame where new discoveries may be recorded and compared, I have composed it of all the American Tertiary species until now described and published, excepting, however, the 56 species from Alaska in Heer's *Flora Alaskana*, which rather pertain to the Arctic flora. The table shows, however, the North American Tertiary plants identical with Alaska species. I have also omitted the fossil plants from Vancouver, the Orcas Islands, and Nanaimo, not only on account of their as yet unascertained geological relation, but also of our imperfect acquaintance with their specific characters. Dr. Evans's specimens are still accessible, and I hope soon to have an opportunity of reviewing them, of comparing them with former descriptions, and to give for a next report a definitive account of the forms which they represent.

This table is, I think, easily understood. The first three sections, marked *Middle Miocene*, *Lower Miocene*, and *Eocene*, are as yet hypothetically limited. The reasons of this limitation, and the characters of the sections as resulting from the species admitted into each of them, will be examined hereafter. The fourth section, marked *Unknown*, has the species from localities not satisfactorily known, either on account of the two small number of specimens representing them, or from want of reliable reference. In the three sections marking stages of the European Tertiary, the relation of our Tertiary species with those of Europe is

indicated by A, *analogous*, and I, *identical*. The table, therefore, is distributed as follows:

1st column, Middle Miocene, has the species from—
H. Henry's Fork.
M. Muddy Creek.
B. Barrell's Springs.
E. Elko Station.

2d column, Lower Miocene, has—
Y. Yellow Stone, } Species described by Dr. Newberry.
U. Fort Union, }
R. Rock Creek.
W. Washakie group.
M. Medicine Bow.
J. Junction Station.
C. Carbon Station.

3d column, Eocene, has—
H. Mississippi flora, from Hilghard's and Safford's specimens.
M. Marshall mine.
R. Raton Pass, with Purgatory Cañon and Gold City.
W. Washakie Station.
E. b. Evanston, below the coal.
E. a. Evanston, above the coal.
S. Snake River.
6 m. Six miles above Spring Cañon and ten miles west of Hot Springs.
Y. Yellowstone Lake.

4th column, Unknown, has–
G. Green River.
P. Point of Rocks.
S. Sage Creek.
M. Mouth of Spring Cañon.
U. Unknown locality.

In the Arctic series we have for references—
G. Greenland.
M. Mackenzie.
S. Spitzbergen.
I. Iceland.
B. Baltic.

Table of distribution of the species of fossil plants in the Tertiary formations of North America.

Name of species.	Middle Miocene.	Lower Miocene.	Eocene.	Unknown.	Alaska.	Arctic.	Europe.		
							Upper Miocene.	Middle Miocene.	Lower Miocene.
Sclerotium pustuliferum, H				U.			T.		
Onoclea sensibilis, L		U.							
Pteris pennæformis, H	H. M.								I.
Blechnum Göpperti, Ett	H.						I.	I.	
Aspidium Fischeri, H	M.						I.	I.	
Gymnogramma Haydenii, Lx			S. R.						
Lygodium compactum, Lx			M.						
neuropteroides, Lx	B.								A.
Fern, species				S.		G.			
Equisetum Haydenii, Lx	B.						A.	A.	
limosum, L., (living)			Y.						
Taxodium occidentale, Ny		Y.							
Tinajorum, H	B.				A.				
Glyptostrobus Europeus, Br		U.			A.	B. G. M.	I.	I.	I.
Sequoia Heerii, Lx				S.	A.	G.			
Langsdorfii, Br		Y.			A.	G. M. B.		I.	I.
Thuja gracilis, Ny		Y.							
Abietites dubius, Lx			M.						
Salisburia binervata, Lx			H.						
Arundo, species			R.						
Phragmites Oeningensis, Br	H. B. E.	W.				G. S. B.	I.	I.	I.
Alaskana, H			6 m.		A.		A.	A.	A.
Poacites lævis, H	B. E.					S.	I.		
Cyperites, species	H.	C.							
augustior, (?) Br			Y.				A.		
Deucalionis, H	B.					B.		I.	I.
Cyperus Braunianus, H	B.						I.		
Chavanensis, H			E. b.						I.
Carex tertiaria, (?) H	M.					B.			I.
Sabal Grayana. Lx			H.					A.	
Campbellii, Ny		Y.						A.	
major, (?) Un	B.							I.	I.
Calamopsis Danai, Lx			H.					A.	
species (?)	H.								
Sparganium, species	B.								A.
Acorus brachystachys, H		W.				S.			
Psilotum inerme, Ny		U.							
Zingiberites, species	H.					B.			I.
Liquidambar gracile, Lx			W.				A.	A.	
Populus rotundifolia, Ny. } subrotunda, Lx.		R.							
arctica, H		M. J.	E. b.	U.		G. M. S.			
smilacifolia, Ny		U.							
attenuata, Br		R.					I.		
cuneata, Ny		Y.					A.		
cordata, Ny		Y.					A.		
acerifolia, Ny		U.							
Nebrascensis, Ny		Y.							A.
genetrix, Ny		Y.							
nervosa, Ny		Y.							
monodon, Lx			H.					A.	
æqualis, Lx		R.					A.		
mutabilis, var. repando-crenata, H.			H. E.				I.		
mutabilis, var. lancifolia, H			6 m.			B.	I.		
balsamoides, (?) Gp			6 m.		A.		I.		
ovalis, Gp			E. b.				I.		
latior var. transversa, Br			W.		A.		I.		
var. cordifolia, Ll		M.					I.		
leucophylla, Un			6 m.		A.		I.		
Zaddachi, H			E. b.		A.	G. B. S.			
Salix Grœnlandica, H			6 m.			G.			
Worthenii, Lx			H.						
densinervis, Lx			H.						
tabellaris, Lx			H.				A.		
Myrica ambigua, Lx			6 m.						
Alnus Kefersteinii, H			E. b.		A.	B. S. I.			I.
serrata, Ny		Y.							A.
Betula caudata, Gp			E. b.				I.		
Stevensoni, Lx			E. b.				A.		
Planera microphylla, Ny		U.					A.	A.	A.
Celtis brevifolia, Lx			H.						
Quercus Moorii, Lx			H.						

Table of distribution of the species of fossil plants, &c.—Continued.

Name of species.	Middle Miocene.	Lower Miocene.	Eocene.	Unknown.	Alaska.	Arctic.	Europe. Upper Miocene.	Europe. Middle Miocene.	Europe. Lower Miocene.
Quercus Lyellii, H.			H.			G.		I.	
retracta, Lx			H.				A.	A.	A.
chlorophylla, Un			H. M.				I.	I.	I.
semi-elliptica, G	E.						I.		
aemulans, Lx			W.						A.
negundoides, Lx			W.						
Drymeja, Un			W.			G.	I.	I.	I.
acrodon, Lx		R.							
Haydenii, Lx		R.							
Gaudini, Lx				M.			A.	A.	A.
Ellisiana, Lx			6 m.				A.		
Pealei, Lx			6 m.				A.		
Godeti, H.			6 m.						I.
Laharpi, G			6 m.			G.			
Saffordi, Lx			H.						
Ilicoides, H				S.					I.
dubia, Ny		Y. (?)							
myrtifolia, (?) Wil			H.						
Corylus grandifolia, Ny		U.							
orbiculata, Ny		U.							
Americana, Ny		U.							
rostrata, Ny		U.							
McQuarryi, H			W. 6 m.		A.	G. M. I. S.			
Fagus Antipofii, H.				P.	A.				
Deucalionis, Un			W.			G. S. I.			
ferruginea, (?) Mx., (fruit)			H.						
Ficus Schimperi, Lx			H.				A.		
cinnamomoides, Lx			H.						
tiliæfolia, Br			R. 6 m.	U.		B.		I.	I.
lanceolata, H				U.		B.	I.		I.
multinervis, H				U.				I.	I.
arenacea, Lx				U.			A.		A.
Gaudini, Lx				U.					
Platanus Haydenii, Ny		M. Y. C.							
nobilis, Ny		Y.	E. a.						
Raynoldsii, Ny		Y.							
heterophylla, Ny		(?)							
Guillelmæ, H.		M.		G. P.		G.	I.		
aceroides, Gp		R. C.				G. M. I. S.	I.		
species				U.					
Laurus pedata, Lx			H.				A.		
Persea lancifolia, Lx			H.						
Sassafras, species			6. m.						
Cinnamomum affine, Lx			M.					A.	A.
Mississippiense, Lx			H.				A.	A.	A.
Scheuzeri, H.			E.a.6 m.	M.	B.	I.	I.	I.	I.
polymorphum, (?) Br				U.			I.	I.	I.
Eleagnus inæqualis, Lx			H.				A.		
Banksia Helvetica, H.			H.					I.	I.
Aristolochia cordifolia, Ny		Y.							
Andromeda Grayana, H.			E.b.6 m.		A.				
dubia, H			H.					I.	
reticulata, H			6 m.			B.			
vaccinifolia, Un			H.			B.			
Diospiros lancifolia, Lx			E. b.		A.				
stenosepala, H.			S.		A.				
Sapotacites Americanus, Lx			H.						
Echitonium Sophiæ, Web			M. R.			B.	I.	I.	
Viburnum asperum, Ny		U.							
lanceolatum, Ny		U.							
Aralia triloba, Ny		Y.							
Cornus incompleta, Lx			M.						
acuminata, Ny		Y.	W.						
Studeri, H.			E. b.					I.	I.
Lyriodendron, species			6 m.			G.			
Magnolia, species			W.			G. (?)			
Hilgardiana, Lx			H.						
laurifolia, Lx			H.						
Lesleyana, Lx			H.						
ovalis, Lx			H.						

Table of distribution of the species of fossil plants, &c.—Continued.

Name of species.	Middle Miocene.	Lower Miocene.	Eocene.	Unknown.	Alaska.	Arctic.	Europe.		
							Upper Miocene.	Middle Miocene.	Lower Miocene.
Magnolia, cordifolia, Lx			H.						
Acer, species	E.								
Do.			R.						
trilobatum, (?) Stb			E. b.				I.	I.	I.
Negundo triloba, Ny		U.							
Sapindus affinis, Ny		Y.							
membranaceus, Ny		U.							
undulatus, Br.			H.				I.		
Ceanothus Meigsii, Lx			H.						
Paliurus Colombi, H		W.				G. S.			
Berchemia parvifolia, Lx			R.				A.		A.
Rhamnus elegans, Ny		U.							
marginatus, Lx			H.						
obovatus, Lx			R.						
salicifolius, Lx			M.						A.
intermedius, Lx			W.						A.
rectinervis, H.			E. a. 6 m. Y.						I.
Tilia antiqua, Ny		U.							
Rhus Evansii, Lx			E. b.						A.
nervosa, Ny		U.							A.
Juglans appressa, Lx			H. E. b.					A.	A.
Saffordiana, Lx			H.						
acuminata, (?) H.			W.		A.	G.	I.	I.	I.
rugosa, Lx			M. R. W. 6 m.		A.	G.	A.	A.	A.
Rhamnoides, Lx			E. b.		A.	G.	A.	A.	A.
denticulata, H			6 m.			G.			
Carya Heerii, Ett.				G.		B.	I.	I.	
antiquorum, Ny		Y.	E. b.						
Amelanchier affinis, Ny		Y.							
Calycites polysepalus, Ny		Y.							
Phyllites venosus, Ny		U.							
carnosus, Ny		U.							
cupanioides, Ny		U.							
truncatus, Lx			H.						
sulcatus, Lx			M.						
Carpolithes lineatus, Ny		U.							
cocculoides, H		C.		U.		G.			

§ 3. Geographical Distribution of American Tertiary Fossil Plants.

A few general remarks applicable also to the considerations on the stratigraphical distribution of our fossil plants find their place in the beginning of this article.

The species marked in the first column of the table do not give any reliable information on geographical or geological distribution. The swamps of the Tertiary, at least those which have preserved remains of plants for fossilization, were evidently of the same kind as are now our forest swamps and bogs. When the swamps were of small extent, the borders being surrounded by trees of course, their interior surface was covered with a thick growth of shrubs mostly of the same species. Such swamps of ours now are bordered by maple, hickory, oak, &c., and their interior surface generally covered by water for a part of the year is occupied by thickets of *Cephalanthus*, *Rosa*, *Azalea*, *Clethra*, &c. When of some larger extent, the middle of the swamps was, at the Ter-

tiary epoch, as it is at our time, merely overgrown by *Ferns*, *Gramens*, and *Cyperaceæ*, while the borders only had shrubs and trees. It is not, therefore, uncommon to find at the same level and in the same strata at one place remains only of herbaceous species, grasses, rushes, ferns, &c., while at a short distance we have at another locality only petrified arborescent leaves. Therefore the accumulation of fossil remains of the first class at one peculiar place is merely casual, and is of not much account in considering the question of distribution. It may be remarked, also, that at the Tertiary epoch, as at our time, groups of few species grow at the same time over or around the same swamps; and that, therefore, we must expect to find the specimens of the same locality representing few species, while on the contrary, at distant localities, equivalent strata have species far different, and which sometimes do not appear to bear relation of age to the others. It is only in the bogs, especially in those from the Ohio River southward, where deposits of peat are generally formed, that there is a diversity of vegetation resembling that which appears in the variety of species found in some localities of our Tertiary strata; as at Evanston, for example, at Marshall, or at the station marked "Six miles above Spring Cañon," &c. In Alabama, Virginia, Arkansas, &c., most of these large bogs of our time are overspread by a luxuriant vegetation of trees, shrubs, even reeds and mosses, in a constant and admirable variety. This vegetation bears, in a remarkable manner, the essential characters represented by the specimens of the Tertiary flora from localities remarked above. For example, in the Dismal Swamp, the magnolias are in such abundance that the farmers of the country obtain from them a fair income by the production of honey. The trees attain around Drummond Lake more than one hundred feet in height. Is not that a remarkable coincidence with the Mississippi Tertiary flora, where on less than twenty species, five represent magnolias with very large leaves? In crossing, in Arkansas, one bog of this kind, no more than one mile in width, I counted thirty-six species of trees and shrubs representing *Magnolia*, *Berchemia*, *Rhamnus*, *Gymnocladus*, *Liquidambar*, *Cornus*, *Viburnum*, *Ilex*, *Clethra*, *Azalea*, *Vaccinium*, *Sassafras*, *Benzoin*, *Juglans*, *Carya*, *Myrica*, *Betula*, *Taxodium*, &c., with five species of oak. The remains of all these living vegetables if petrified would show a collection of types, if not of species, remarkably similar to what is found now in some of the named localities of the Tertiary formations.

A comparison of geographical distribution of Tertiary species, under about the same degrees of latitude, is now possible only in a general way, and between Europe and North America. The points of difference and analogy may be seen at a glance on the table, without a tedious repetition of names. I will therefore add only the remarks which may give more light to the subject.

Some families of plants have at our time a wide range of distribution, the *Gramineæ*, for example, the *Cyperaceeæ*, the *Amentaceæ*, which, at least in England, have one-half of the species identical with ours. We may then expect to find, in the distribution of genera and species of these orders of plants, a striking analogy between the Tertiary plants of both continents. The table indicates about the same proportion of representatives of these families at the Tertiary epoch as there is at our time. Of the poplars, for example, we have twenty fossil species, of which eleven are identical with Tertiary species of Europe. This genus indicates, by its fossil representatives, a great predominance of species for our country. Perhaps some forms of ours which have been considered as distinct may be reduced by subsequent observations to mere varie-

ties. But it is remarkable that the same predominance is continued in our present flora, as we have, in counting the marked varieties, twice as many species of poplars as are found in Europe under the same latitude. The willows show in their distribution the same analogy, but in a contrary way. As yet we know only four species of *Salix* from our Tertiary measures, while Europe has thirteen. And this difference is the more remarkable that we have in our Cretaceous already five species of this genus. But, in considering our present flora, we find for Europe thirty-four species of willows, while we count only twenty-one for North America—six of them at least introduced from Europe. Of oaks, Europe has thirty-five Tertiary species on nine hundred and twenty species of plants known from this formation, or about one twenty-fifth, while this genus as yet represents one-tenth of our Tertiary species. Therefore, here also we see the preponderance of this genus in our actual flora indicated already in the Tertiary. The same can be said for *Platanus*, *Magnolia*, *Rhamnus*, and *Juglans*. Most of the genera, about equally represented in Europe and in America, and of which no living species are found now in the flora of the old continent, have still representatives with us; as, for example, *Sequoia*, *Sabal*, *Liquidambar*, *Ficus*, *Laurus*, *Sassafras*, *Liriodendron*, *Magnolia*, *Negundo*, *Carya*, &c. Of genera represented in the North American Tertiary and not in the European Miocene, like *Celtis*, we have still living species also. On the other side, of some genera or orders which had a marked number of species in the Tertiary of Europe and none in ours, like the *Daphnoides*, the *Proteaceæ*, the *Myrsineæ*, none appears in our present flora.

The same comparison pursued in a contrary direction, or in regard to difference in latitude, indicates a relation of our Tertiary flora with that of the Arctic regions.* Five of our species marked as of a wide distribution—one *Fern*, three *Conifers*, one *Phragmites*, one *Acorus*—have identical representatives in Greenland and Spitzbergen. Of species of a lesser range, we have in both *Populus arctica*, *P. Zaddachi*, *Alnus Kefersteinii*, *Quercus Lyellii*, *Q. Drymeja*, *Q. Laharpi*, *Corylus McQuarryi*, *Fagus Deucalionis*, *Platanus Guillelmæ*, *P. aceroides*, one species of *Liriodendron*, one of *Magnolia*, *Paliurus Colombi*, five species of *Juglans*, (perhaps reducible to two,) about one-eighth of our whole Tertiary flora, or twenty-four species, eleven of which are also in the same formation of Europe. With the Alaska Tertiary flora, of which only fifty-six species are known, we have eighteen identical species, ten of which are also in the Miocene of Europe; and with the Baltic flora, fourteen, two of which only, *Populus Zaddachi* and *Andromeda reticulata*, are not marked in Heer's Fl. Ter. Helv. These data are scanty, indeed; but they indicate already between our North American Tertiary flora and that of the arctic regions an intimate relation, considering the difference of latitude, closer, indeed, (one-fifteenth,) than with the European Tertiary, (one twenty-sixth.) At the same time, the evidence is against a more marked analogy than could be surmised from the difference of latitude; for in comparing the types of both groups of fossil plants of the arctic and of the North American Tertiary, the northern and southern facies are distinctly recognized. The arctic flora, including Alaska, has no *Cinnamomum*. These so wide-spread representatives of a warmer climate in the Tertiary are first seen in Vancouver and in our North American Tertiary, as far up as Fort Union, near the 48° of latitude. It has also no *Sabal*, while immense and numerous leaves of this species character-

* The comparison is made from the species enumerated in the table, including those of Mississippi, with the Arctic Tertiary Flora of Heer, which describes the Tertiary plants of Greenland, Spitzbergen, Mackenzie, and Iceland.

ize our Tertiary, even to the same latitude of 48°. South, in the Mississippi Tertiary, the palms appear with more tropical forms, or with the pinnately divided fronds of *Calamopsis.* Other genera represented in warmer regions—*Lygodium*, *Ficus*, *Laurus*, &c.—have no species in the arctic flora, and of our nineteen Tertiary species of oaks three only are indicated in the Greenland flora, *Quercus Drymeja*, *Q. Laharpi*, *Q. Lyellii*, all common to the whole extent of the Tertiary formations. One species of *Magnolia*, described in the Arctic Flora, appears like an exception to the general rule of geographical distribution of plants, according to climate, as in the Tertiary strata of Mississippi five well characterized species of this genus have been discovered, while there is but one as yet from the northwestern Tertiary. This is probably the result of the peculiar distribution observed at our time for species of magnolias. They live generally grouped in small areas, often at great distances from each other, and without apparent regard to climatic circumstances. Though I have traveled nearly over the whole extent of the coal-basin of Pennsylvania, I never met magnolias but on Silvery Rock Creek, in the upper part of Butler County, where there is in the bottom of the creek a group of one dozen or more of large trees of this species. The same kind of grouping of these fine trees is remarked in Kentucky and Tennessee.

The Tertiary species common to the flora of both the arctic and the North American Tertiary seem to indicate for the plants of this formation a wider range of distribution than ours have now. But it is not necessary to admit that the whole Tertiary land now known on our continent was occupied at the same time by the same class of vegetation. These so-called Tertiary formations may have been in progress at different places during a long period of time, and the land-surface successively invaded by vegetation. Supposing a slow upheaval of the Tertiary land, beginning at the north, with there a relative lowering of temperature, the plants of that region may have by slow degrees migrated southward and been introduced upon a more recently emerged land of the same epoch. Even without admitting this hypothesis, which cannot be here sufficiently developed, and which is not as yet sustained by positive evidence, a comparative wide range of distribution is remarked at our time for some species related to those of our Tertiary. For example, *Magnolia*, *Lyriodendron*, *Liquidambar*, seen as high as the 41° and 42° of latitude north, descend to South Florida, a difference of about 15°. More common species, especially those which generally inhabit the swamps and bogs, like *Prunus Americana*, *Amelanchier Canadensis*, *Vaccinium corymbosum*, range from Middle Florida to the northern shore of Lake Superior, on more than 20° of latitude. The same range may be assigned to *Acer saccharinum*, *Quercus rubra*, *Fagus ferruginea*, *Corylus Americana*, *Juniperus Virginica*, all species intimately related to species of our Tertiary. The average of latitude of the Tertiary deposits, where the Greenland leaves, described by Heer, were obtained, is 70° north. We may place the average latitude of the North American Tertiary, at least for Dr. Hayden's plants, at the 45°. This is 25° of latitude for the distribution of some species of wide range of the Tertiary, a difference of 5° only in comparing this distribution with that of our living plants, and which is easily accounted for by the evenness of the land, together with the greater atmospheric humidity and more uniform climate of the northern hemisphere at the tertiary epoch. This fact is rendered evident by the great deposits of coal of that formation.

The land connection of Greenland, Spitzbergen, &c., with our continent during the Tertiary period seems attested by the distribution of the

North American Tertiary flora. The examination of this question would demand more details than I can give in this abridged report.

§4. STRATIGRAPHICAL DISTRIBUTION OF FOSSIL PLANTS IN THE NORTH AMERICAN TERTIARY FORMATIONS.

Remarks on this subject cannot be definite and conclusive, the materials obtained being as yet too scanty to furnish valuable information. The table of distribution of the fossil plants of the Miocene of Europe, as established by Heer, as a complement of his admirable work, *Flora Tertiaria Helvetica*, enumerates nine hundred and twenty species, marking their habitat in three essential divisions, corresponding with Upper Miocene, Middle Miocene, and Lower Miocene.* Very few of these species are represented in a single stage or on the same division in the different geographical sections of the European Tertiary, and, therefore, few, if any, of these species may be considered as leading and characteristic of one of these stages. Of course, one hundred and ninety species could not but afford less decisive indications. The relation indicated by the North American fossil species, now under consideration, with European species, is intimate and evident enough to demonstrate that these plants of ours are of Tertiary age, as it has been already surmised by the comparisons of the former chapter. Of the one hundred and ninety forms of our leaves enumerated, one-fourth (45) are identical with species of the Miocene of Europe, and one-fifth (33) closely allied to species of the same formation; but nothing more can be ascertained; and a reference of these plants, per groups at least, to any stage of the European Tertiary, would be mere hypothesis. This assertion is proved by the following table, which indicates from each of our divisions the number of American species identical with species of the different stages of the Miocene of Europe:

		EUROPE.					
		Upper Miocene.	Both Upper and Middle Miocene.	Middle Miocene.	Both Middle and Lower Miocene.	Lower Miocene.	In the three divisions.
America.	Middle Miocene	3	2	......	2	2	1
	Lower Miocene	2	......	2	1	......	2
	Eocene	8	1	2	3	4	5
	Unknown	1	1	......	2	1	1

This table is explicit. It shows that species of each of our divisions are nearly equally scattered in the various stages of the Miocene of Europe, and that about one-half of them are identical with species pertaining at least to two of these stages.

On what kind of evidence are then based the divisions of our own table? On the succession of strata as established by geological observations. The station of some of these strata, especially of those more interesting by the large number of fossil plants obtained: Marshall, Raton Pass, Evanston, six miles above Spring Cañon, &c., is in such close connection to Cretaceous strata that it is as yet not possible to point out a line of division, and that they are therefore classed in the category

* Heer, *loc. cit.*, p. 351–369. The divisions are differently marked for Switzerland, France, Germany, and Italy. The essential points only are indicated here.

of disputed ground. It even appears that, in some case at least, fossil animals vouch for their Cretaceous relation.* It is the same case with the fossil plants described from Mississippi and Tennessee.† They were at first considered, from geological evidence, as Cretaceous, and have been definitely admitted as of the Eocene age.‡ The relation of the species examined here from specimens of Dr. Hayden, and which are placed in the Eocene section of the table, have the same general character as those of the Mississippi, and are evidently of the same age. Admitting, therefore, the third section of the table for plants of the Eocene, the species of the second section must be referred to the Lower Miocene. They differ by their general facies from those of the third section, and the strata with which they are connected have been recognized as of a higher geological horizon. The first division of the table, marked Middle Miocene, is by its flora indefinite, its species, as already remarked, having relation to all the stages of the Tertiary.

It will not be possible to know anything of the characters of the flora of the different stages of our North American Tertiary except after prolonged and careful researches; for in trying to ascertain the species of plants pertaining to a peculiar division of an epoch, the results appear to be the same for the Tertiary as for the Carboniferous formations. Local groups are generally well limited; their characters are at first considered as resulting from difference of age. But more extended researches show identical vegetable forms at other places of evidently different horizons, forcing the conclusion that most generally, at least, geographical distribution is the essential cause of the diversity of vegetable groups in the same formations.

§ 5. Typical Analogy of the present Flora of North America with Tertiary and Cretaceous Species.

I have already alluded in a general way§ to this fact: that the essential types of our actual flora are marked in the Cretaceous, and have come to us after passing, without notable changes, through the Tertiary formations of our continent. Before any species of our Tertiary had been recognized and described, the general facies of the European Miocene had been compared to that of the present North American flora, and from the remarkable analogy of the vegetation of both epochs, the conclusion had been driven, that the present flora of ours had received its essential representatives from species migrated from the European Tertiary. If the assertion brought forth in the beginning of this chapter is right, the contrary conclusion is true; that is, the Tertiary flora of Europe is essentially a compound of American types, and our Cretaceous flora is the ancestor as well of our present flora as of that of the Tertiary of Europe. It is worth while, therefore, to briefly consider the essential proofs of this assertion, reserving for a future report a detailed exposition, which may be rendered more conclusive by the collecting of new materials.||

* Dr. F. V. Hayden in letters.

† Species of Fossil Plants from the Tertiary of Mississippi, in Trans. Am. Phil. Soc., vol. XIII, pp. 426 and 427.

‡ The discussion on the age of these strata is clearly and thoroughly exposed in Danas's Manual of Geology, pp. 509–511. See also F. V. Hayden's Annual Report for 1870, p. 383.

§ American Journal of Science and Arts, vol. XLVI, p. 104.

|| The word *type* is here used in its more general sense, as a *figure of something to come*, without considering antecedence. In that way it is more acceptable than the word *race*, which rather offers an idea of derivation.

No species of *Glumaceæ* is as yet known from the Cretaceous formations of this continent, but from uncertain remains, knots separated from the stem, and a piece of a stem referable to the genus *Arundo*. As *Glumaceæ* and *Cyperaceæ* are largely represented in the Tertiary, we may expect to find types of these orders of plants in some strata of the Upper Cretaceous, their distribution being local, as remarked formerly. *Per contra*, the Cretaceous has already typical representatives of the essential sections of the *Gymnospermæ*, as they are seen later in the Tertiary and now in our flora. The *Cupressineæ* are represented by *Glyptostrobus gracillimus*, Lsqx.; the *Abietineæ*, by *Araucaria* (?) *spathulata*, Newby, *Sequoia formosa*, Lsqx., a cone of *Abietites* described as *Pterophyllum*, (?) Lsqx., all these from Nebraska and *Sequoia Reichenbachi*, Heer, from Montana. These are followed in the Tertiary by a number of forms of *Taxodium*, *Glyptostrobus*, *Sequoia*, &c., all repeated without striking variations in our flora. *Sequoia* is well represented in the Miocene of Europe; but this genus has disappeared from its flora, as also from our northeastern American flora, being still distributed in California. The type of our *Abies* appears to be *Araucaria spathulata*, named above, a form referable to three species of *Abietites*, described by Dunker from the Quadersandstein of Blankenburg, and which, altogether, may represent a single species. As yet we have no remains of *Pinus*, neither from the Cretaceous nor from the Tertiary. Heer has, however, described two species from the Cretaceous of Greenland, and twenty-four species from the arctic Tertiary. That they have not been found yet in the North American measures, is merely the result of the geographical distribution of the species of this genus. A remarkable group of the *Taxineæ*, represented already in our Cretaceous by one species of *Phyllocladus*, and in the Lower Tertiary by a *Salisburia*, is out of our present flora. The species of the first genus inhabit New Holland and Tasmania; the other has only one living representative species in Japan. Nothing can be said on the causes of migration, and extinction of vegetable types. As Australia has now animal species analogous to those of the Cretaceous, it would not be peculiar to find there also the same kind of analogy for plants. Species, especially of conifers, disappear without appreciable causes, as some of them are now dying out at our time; the cedar of Lebanon, the pine (*Pinus cembra*) of the Alps, the giant trees of California, (*Sequoia*, &c.) That our climate is well appropriate to the vegetation of *Salisburia adiantifolia* is proved by the result of its culture. There is in the row of trees bordering the Common of Boston, a splendid representative of this species, with a trunk about one foot in diameter. It has never been sheltered, and is there mixed with elms and other indigenous species.

But the conifers do not furnish the essential characters to our present arborescent flora. Most of the trees of our forests belong to the first division of the dicotyledonous plants, that of the apetalous; the sweet-gum, the willow, the poplar, the oak, the beach, the elm, &c., are of this kind.

Already one species of *Liquidambar* is known from its remains in the Cretaceous, *L. subintegrifolius*, intimately related to another species, *L. gracile*, of the Lower Tertiary of the West. Both are remarkable for the entire borders of the leaves; but for this, the form of the Cretaceous leaf is similar to that of *L. styraciflua*, our sweet-gum. Two species are also represented in the Miocene of Europe. Of the poplars, already seven species have been described from the Cretaceous of Nebraska. The types of our actual species are marked there already, and more still in the species of the Tertiary, (21,) some of them identical with those of the same formation of Europe. The willows have five species in the

Cretaceous, also representing typical forms of our living species. Their presence in the Tertiary is attested, as far as we know yet, by four species. The oaks of our living flora, with the great diversity of forms of their leaves, have, also, their primitive types in species of the Cretaceous. One type, that of the leaves with entire borders, like *Quercus Phellos*, *Q. Imbricaria*, being distinctly marked, especially in *Q. salicifolia*, Newby.; *Q. anceps*, Lsqx.; *Q. Ellsworthiana*, Lsqx., while the type of the chestnut-oaks is essentially represented by *Q. primordialis*, Lsqx. The same types traverse our Tertiary flora, and there multiply in the nineteen species of Tertiary forms, analogous, some of them at least, to species distributed at our time in Northeastern and in Northwestern America. For the beach, the leaves of our Cretaceous species, also diversified in forms, while traversing the Tertiary, are scarcely distinguishable from those of the living species. Even the chestnut appears to be represented in the Cretaceous by a species which I refer to *Quercus*, viz, *Q. Mudgii*, on account of the branching of a few of the secondary veins, but which is a true *Castanea* by the divisions of the leaves. After this we have in our Cretaceous, with fewer but well specified representatives, *Betula* in *B. Beatriciana*, Lsqx., *Alnus* or *Corylus* in a large leaf *Alnus* (?) *grandifolia*, Newby.; *Ficus* in leaves of a type recognizable in numerous forms of this genus in our Tertiary, with species of *Laurus*, *Sassafras*, and *Cinnamomun*, all, except the last, types of living species of the North American flora. One of the three forms of sassafras of our Cretaceous is, by its leaves, undistinguishable from our living species. The genus *Platanus* also has its Cretaceous type preserved to our time with scarcely any variation of form in one species, which I have referred to *P. aceroides*, Göpp., and which is scarcely distinguishable from our *P. occidentalis*. In the Tertiary we know already a number of remarkable species of this genus, which now has a single representative on our continent, and is apparently disappearing from the present flora.

The second section of the dicotyledonous, the monopetalous, is not largely represented in North America by arborescent species. We have especially shrubs. However, *Diospiros* and *Andromeda* have their types marked in the Cretaceous. And in the third section, the polypetalous, our *Liriodendon*, *Magnolia*, *Acer*, *Rhamnus*, *Aralia*, *Juglans*, even apparently *Prunus*, whose species are still predominant, have all typical representatives in the Cretaceous of ours.

It would be interesting to pursue these researches with more details, and to follow some specific forms in their development through the Tertiary; but mere descriptions are insufficient without figures for such a kind of comparison.

Some of our now living species, of course, have not as yet any recognized types in the Cretaceous, perhaps, because the researches have not been pursued over a wide extent of this formation. Nevertheless, these Cretaceous leaves of ours have a *facies* with which some of the present forms do not agree. They are all either entire, or lobed, or with borders merely undulate. No serrulate or doubly serrate leaf has been recognized among them, and, as far as it is known till this time, all the genera whose species have leaves of this kind, like *Alnus*, *Carpinus*, *Ostrya*, *Ulmus*, (?) *Fraxinus*, *Vitis*, *Tilia*, are not in the Cretaceous. The large leaf referred to *Ulmus*, (?) by Dr. Newberry, has the borders undulately and obtusely lobed; even the Cretaceous species of *Acer* are merely three-lobed, with obtuse lobes and entire borders. It will be interesting to study the apparent absence of these forms in the Cretaceous, and, if real, to observe in the Tertiary the origin of what we may call a new type and the transitions to it.

Some other groups of plants represented in the Tertiary flora of Europe, and without representatives in our present flora, are not seen, as it has been remarked already, in the North American Cretaceous and, Tertiary, the *Proteaceæ*, the *Myrtaceæ*, for example. The total absence of a group which, like that of the *Proteaceæ*, has, in the Miocene flora of Europe, thirty-five species, is the best proof we may have of the homogeneity and indigenous origin of our flora. Shall I say of its antiquity too? Facts seem to indicate for our flora, as for our race, a northern origin. Our types may have risen in Greenland and gradually passed southward, some of them branching to Europe. But as these types of old have been preserved to us only, we may at least admit what Agassiz calls "the more ancient character of our flora, which bears the mark of former ages, a particularity which agrees with the geological structure, and indicates that this region was a large continent long before extensive tracts of land had been lifted above the level of the sea in any other part of the world." *

SUMMARY.

The recapitulation of the essential data pointed out by the examination of the Tertiary and Cretaceous specimens of Dr. Hayden's collection of fossil plants presents the following conclusions:

1st. The Tertiary flora of North America is, by its types, intimately related to the Cretaceous flora of the same country.

2d. All the essential types of our present arborescent flora are already marked in the Cretaceous of our continent, and become more distinct and more numerous in the Tertiary; therefore the origin of our actual flora is, like its *facies*, truly North American.

3d. Some types of the North American Tertiary and Cretaceous flora appear already in the same formations of Greenland, Spitzbergen, and Iceland; the derivation of these types is therefore apparently from the arctic regions.

4th. The relation of the North American Tertiary flora with that of the same formation of Europe is marked only for North American types, but does not exist at all for those which are not represented in the living flora of this continent. Therefore the European Tertiary flora partly originates from North American types, either directly from our continent or derived from the arctic regions.

5th. The relation of the Tertiary flora of Greenland and Spitzbergen with ours indicates, at the Tertiary and Cretaceous epochs, land connection of the northern islands with our continent.

6th. The species of plants common to the Cretaceous and Tertiary formations of the arctic regions and of our continent indicate, in the mean temperature influencing geographical distribution of vegetation, a difference, in +, equal to about 5° of latitude for the Tertiary and Cretaceous epochs.

7th. The same kind of observations on the geographical distribution of vegetable species shows at the Tertiary and Cretaceous times differences of temperature according to latitude, analogous to what is remarked at our time by the characters of the southern and northern vegetation.

To these important conclusions, the examination of Dr. Hayden's specimens indicates some of the essential points which should be taken into consideration for directing future researches:

1st. As we have not yet sufficient points of comparison between the fossil flora of the eastern and that of the western slopes of our continent,

* Lake Superior, its physical character, &c., by L. Agassiz, p. 150.

acquaintance with the Tertiary and Cretaceous species of California is most desirable. The marked differences in the present floras of these slopes may be explained by the fossil species. Are these differences a result of the topography of the country as fixed at or after the Tertiary, or do they already originate in geographical distribution at the Tertiary and Cretaceous times?

2d. We have no sufficient knowledge as yet with the North American Tertiary plants to positively indicate if any stages are marked in this formation by difference in the vegetation.

3d. A close study of the plants from the so-called disputed strata, which in superposition to Cretaceous formations appear to have at one place Tertiary types, at another Cretaceous ones, is desirable, in order, if possible, to discover transitional or intermediate forms indicating gradual changes from the Cretaceous to the Tertiary flora.

4th. In the same way and for the same purpose it is most desirable to have a better acquaintance with the fossil plants of the Upper Tertiary formations, considered as of Pliocene age, as those of Mound City, Columbus, Kentucky, near the mouth of the Ohio River, and also with the still more recent deposits of leaves between the mouth of the Cumberland and of the Tennessee Rivers. In these, also, we may expect to see transitional forms of vegetation between the Tertiary flora and ours.

ON THE GEOLOGY AND PALEONTOLOGY OF THE CRETACEOUS STRATA OF KANSAS.

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PART I.—A GENERAL SKETCH OF THE ANCIENT LIFE.

That vast level tract of our territory lying between Missouri and the Rocky Mountains represents a condition of the earth's surface which has preceded, in most instances, the mountainous or hilly type so prevalent elsewhere, and may be called, in so far, incompletely developed. It does not present the variety of conditions, either of surface for the support of a very varied life, or of opportunities for access to its interior treasures, so beneficial to a high civilization. It is, in fact, the old bed of seas and lakes, which has been so gradually elevated as to have suffered little disturbance. Consistently with its level surface, its soils have not been carried away by rain and flood, but rather cover it with a deep and wide-spread mantle. This is the great source of its wealth in nature's creations of vegetable and animal life, and from it will be drawn the wealth of its future inhabitants. On this account its products have a character of uniformity; but viewed from the standpoint of the political philosopher, so long as peace and steam bind the natural sections of our country together, so long will the plains be one important element in a varied economy of continental extent. But they are not entirely uninterrupted. The natural drainage has worn channels, and the streams flow below the general level. The ancient sea and lake deposits have neither been pressed into very hard rock beneath piles of later sediment, nor have they been roasted and crystallized by internal heat. Although limestone rock, they easily yield to the action of water, and so the side drainage into the creeks and rivers has removed their high banks from many rods to many miles from their

original positions. In many cases these banks or bluffs have retained their original steepness, and have increased in elevation as the breaking down of the rock encroached on higher land. In other cases the rain-channels have cut in without removing the intervening rocks at once, and formed deep gorges or cañons, which sometimes extend to great distances. They frequently communicate in every direction, forming curious labyrinths, and when the intervening masses are cut away at various levels, or left standing, like monuments, we have the characteristic peculiarities of "bad lands," or *mauvaises terres*.

In portions of Kansas tracts of this kind are scattered over the country along the margins of the river and creek valleys and ravines. The upper stratum of the rock is a yellow chalk, the lower bluish, and the brilliancy of the color increases the picturesque effect. From elevated points the plains appear to be dotted with ruined villages and towns whose avenues are lined with painted walls of fortifications, churches, and towers, while side-alleys pass beneath natural bridges or expand into small pockets and caverns, smoothed by the action of the wind carrying hard mineral particles. But this is the least interesting of the peculiarities presented by these rocks. On the level surfaces, denuded of soil, lie huge oyster-like shells, some opened and others with both valves together, like remnants of a half-finished meal of some titanic race, who had been frightened from the board never to return. These shells are not thickened like most of those of past periods, but contained an animal which would have served as a meal for a large party of men. One of them measured 26 inches across.

If the explorer searches the bottoms of the rain-washes and ravines, he will doubtless come upon the fragment of a tooth or jaw, and will generally find a line of such pieces leading to an elevated position on the bank or bluff where lies the skeleton of some monster of the ancient sea. He may find the vertebral column running far into the limestone that locks him in his last prison; or a paddle extended on the slope, as though entreating aid; or a pair of jaws lined with horrid teeth, which grin despair on enemies they are helpless to resist; or he may find a conic mound on whose apex glisten in the sun the bleached bones of one whose last office has been to preserve from destruction the friendly soil on which he reposed. Sometimes a pile of huge remains will be discovered, which the dissolution of the rock has deposited on the lower level, the force of rain and wash having been insufficient to carry them away.

But the reader inquires, What is the nature of these creatures thus left stranded a thousand miles from either ocean? How came they in the limestones of Kansas, and were they denizens of land or sea? It may be replied that our knowledge of this chapter of ancient history is only about five years old, and has been brought to light by geological explorations set on foot by Dr. Turner, Professor Mudge, Professor Marsh, W. E. Webb, and the writer. Careful examinations of the remains discovered show that they are nearly all to be referred to the reptiles and fishes. We find that they lived in the period called Cretaceous, at the time when the chalk of England and the green-sand marl of New Jersey were being deposited, and when many other huge reptiles and fishes peopled both sea and land in those quarters of the globe. The twenty-four species of reptiles found in Kansas, up to the present time, varied from ten to eighty feet in length, and represented six orders, the same that occur in the other regions mentioned. Two only of the number were terrestrial in their habits, and two were flyers; the remainder were inhabitants of the salt ocean. When they swam over what are now the plains,

the coast line extended from Arkansas to near Fort Riley, on the Kansas River, and passing a little eastward traversed Minnesota to the British possessions, near the head of Lake Superior. The extent of sea to the westward was vast, and geology has not yet laid down its boundary; it was probably a shore now submerged beneath the waters of the North Pacific Ocean.

Far out on its expanse might have been seen in those ancient days, a huge, snake-like form which rose above the surface and stood erect, with tapering throat and arrow-shaped head; or swayed about, describing a circle of twenty feet radius above the water. Then it would dive into the depths, and naught would be visible but the foam caused by the disappearing mass of life. Should several have appeared together, we can easily imagine tall, twining forms rising to the height of the masts of a fishing fleet, or like snakes twisting and knotting themselves together. This extraordinary neck—for such it was—rose from a body of elephantine proportions; and a tail of the serpent-pattern balanced it behind. The limbs were probably two pairs of paddles like those of *Plesiosaurus*, from which this diver chiefly differed in the arrangement of the bones of the breast. In the best known species 22 feet represent the neck in a total length of 50 feet.

This is the *Elasmosaurus platyurus*, Cope, a carnivorous sea-reptile, no doubt adapted for deeper waters than many of the others. Like the snake-bird of Florida, it probably often swam many feet below the surface, raising the head to the distant air for a breath, then withdrawing it and exploring the depths 40 feet below, without altering the position of its body. From the localities in which the bones have been found in Kansas, it must have wandered far from land, and that many kinds of fishes formed its food is shown by the teeth and scales found in the position of its stomach.

A second species of somewhat similar character and habits differed very much in some points of structure. The neck was drawn out to a wonderful degree of attenuation, while the tail was relatively very stout, more so, indeed, than in the *Elasmosaurus*, as though to balance the anterior regions while occupied in various actions; *e. g.*, while capturing its food. This was a powerful swimmer, its paddles measuring four feet in length, with an expanse therefore of about eleven feet. It is known as *Polycotylus latipinnis*, Cope.

The two species just described formed a small representation in our great interior sea, of an order which swarmed, at the same time or near it, over the gulfs and bays of old Europe. There they abounded twenty to one. Perhaps one reason for this was the almost entire absence of the real rulers of the waters of ancient America, viz, the *Pythonomorphs*. These sea-serpents—for such they were—embrace more than half the species found in the limestone rocks in Kansas, and abound in those of New Jersey and Alabama. Only four have been seen as yet in Europe.

Researches into their structure have shown that they were of wonderful elongation of form, especially of tail. That their heads were large, flat, and conic, with eyes directed partly upward; that they were furnished with two pairs of paddles like the flippers of a whale, but with short or no portion representing the arm. With these flippers and the eel-like strokes of their flattened tail they swam, some with less others with greater speed. They were furnished, like snakes, with four rows of formidable teeth on the roof of the mouth. Though these were not designed for mastication, and, without paws for grasping, could have been little used for cutting, as weapons for seizing their prey they were very formidable. And here we have to consider a peculiarity of these

creatures, in which they are unique among animals. Swallowing their prey entire like snakes, they were without that wonderful expansibility of throat due in the latter to an arrangement of levers supporting the lower jaw. Instead of this each half of that jaw was articulated or jointed at a point nearly midway between the ear and the chin. This was of the ball-and-socket type, and enabled the jaw to make an angle outward, and so widen by much the space enclosed between it and its fellow. The arrangement may be easily imitated by directing the arms forward, with the elbows turned outward and the hands placed near together. The ends of these bones were in the *Pythonomorpha* as independent as in the serpents, being only bound by flexible ligaments. By turning the elbows outward and bending them, the space between the arms becomes diamond-shaped and represents exactly the expansion seen in these reptiles, to permit the passage of a large fish or other body. The arms, too, will represent the size of jaws attained by some of the smaller species. The outward movement of the basal half of the jaw necessarily twists in the same direction the column-like bone to which it is suspended. The peculiar shape of the joint by which the last bone is attached to the skull depends on the degree of twist to be permitted, and therefore to the degree of expansion of which the jaws were capable. As this differs much in the different species, they are readily distinguished by the column or "quadrate" bone when found. There are some curious consequences of this structure, and they are here explained as an instance of the mode of reconstruction of extinct animals from slight materials. The habit of swallowing large bodies between the branches of the under jaw necessitates the prolongation forward of the mouth of the gullet; hence the throat in the *Pythonomorpha* must have been loose and almost as baggy as a pelican's. Next, the same habit must have compelled the forward position of the glottis or opening of the windpipe, which is always in front of the gullet. Hence these creatures must have uttered no other sound than a hiss, as do animals of the present day which have a similar structure; as, for instance, the snakes. Thirdly, the tongue must have been long and forked, and for this reason: its position was still anterior to the glottis, so that there was no space for it except it were inclosed in a sheath beneath the windpipe when at rest, or thrown out beyond the jaws when in motion. Such is the arrangement in the nearest living forms, and it is always in these cases cylindric and forked.

The giants of the *Pythonomorpha* of Kansas have been called *Liodon proriger*, Cope, and *Liodon dyspelor*, Cope. The first must have been abundant, and its length could not have been far from fifty feet; certainly not less. Its physiognomy was rendered peculiar by a long projecting muzzle, reminding one of that of the blunt-nosed sturgeon of our coast; but the resemblance was destroyed by the correspondingly massive end of the branches of the lower jaw. Though clumsy in appearance, such an arrangement must have been effective as a ram, and dangerous to his enemies in case of collision. The writer once found the wreck of an individual of this species strewn around a sunny knoll beside a bluff, and his conic snout pointing to the heavens formed a fitting monument, as at once his favorite weapon, and the mark distinguishing all his race.

Very different was the *Liodon dyspelor*, a still larger animal than the last, with a formidable armature. It was, indeed, the longest of known reptiles, and probably equal to the great finner-whales of modern oceans. The circumstances attending the discovery of one of these will always be a pleasant recollection to the writer. A part of the face,

with teeth, was observed projecting from the side of a bluff by a companion in exploration, Lieutenant James H. Whitten, United States Army, and we at once proceeded to follow up the indication with knives and picks. Soon the lower jaws were uncovered, with their glistening teeth, and then the vertebræ and ribs. Our delight was at its height when the bones of the pelvis and part of the hind limb were laid bare, for they had never been seen before in the species and scarcely in the order. While lying on the bottom of the Cretaceous sea, the carcass had been dragged hither and thither by the sharks and other rapacious animals, and the parts of the skeleton were displaced and gathered into a small area. The massive tail stretched away into the bluff, and after much laborious excavation we left a portion of it to more persevering explorers. The species of *Clidastes* did not reach such a size as some of the *Liodons*, and were of elegant and flexible build. To prevent their habits of coiling from dislocating the vertebral column, these had an additional pair of articulations at each end, while their muscular strength is attested by the elegant striæ and other sculptures which appear on all their bones. Five species of this genus occur in the Kansas strata, the largest (*Clidastes cineriarum*, Cope) reaching 40 feet in length. The discovery of a related species (*Holcodus coryphæus*, Cope) was made by the writer under circumstances of difficulty peculiar to the plains. After examining the bluffs for half a day without result, a few bone fragments were found in a wash above their base. Others led the way to a ledge 40 or 50 feet from both summit and foot, where, stretched along in the yellow chalk, lay the projecting portions of the whole monster. A considerable number of vertebræ were found preserved by the protective embrace of the roots of a small bush, and when they were secured, the pick and knife were brought into requisition to remove the remainder. About this time one of the gales, so common in that region, sprang up, and, striking the bluff fairly, reflected itself upward. So soon as the pick pulverized the rock, the limestone dust was carried into eyes, nose, and every available opening in the clothing. I was speedily blinded, and my aid disappeared in the cañon, and was seen no more while the work lasted. Only the enthusiasm of the student could have endured the discomfort, but to him it appeared a most unnecessary "conversion of force" that a geologist should be driven from the field by his own dust. A handkerchief tied over the face, and pierced by minute holes opposite the eyes, kept me from total blindness, though dirt in abundance penetrated the mask. But a fine relic of creative genius was extricated from its ancient bed, and one that leads its genus in size and explains its structure.

On another occasion, riding along a spur of a yellow chalk bluff, some vertebræ lying at its foot met my eye. An examination showed that the series entered the rock, and, on passing round to the opposite side, the jaws and muzzle were seen projecting from it, as though laid bare for the convenience of the geologist. The spur was small and of soft material, and we speedily removed it in blocks, to the level of the reptile, and took out the remains as they laid across the base from side to side.

A genus related to the last is *Edestosaurus*. A species of 30 feet in length, and of elegant proportions, has been called *E. tortor*, Cope. Its slenderness of body was remarkable, and the large head was long and lance-shaped. Its flippers tapered elegantly, and the whole animal was more of serpent than any other of its tribe. Its lithe movements brought many a fish to its knife-shaped teeth, which are more efficient and numerous than in any of its relatives. It was found coiled

up beneath a ledge of rock, with its skull lying undisturbed in the center. A species distinguished for its small size and elegance is *Clidastes pumilus*, Marsh. This little fellow was only 12 feet in length, and was probably unable to avoid occasionally furnishing a meal for some of the rapacious fishes which abounded in the same ocean.

The flying saurians are pretty well known from the descriptions of European authors. Our Mesozoic periods had been thought to have lacked these singular forms until Professor Marsh and the writer discovered remains of species in the Kansas chalk. Though these are not numerous, their size was formidable. One of them, *Ornithochirus harpyia*, Cope, spread eighteen feet between the tips of its wings, while the *O. umbrosus*, Cope, covered nearly twenty-five feet with his expanse. These strange creatures flapped their leathery wings over the waves, and often plunging, seized many an unsuspecting fish; or, soaring at a safe distance, viewed the sports and combats of the more powerful saurians of the sea. At night-fall, we may imagine them trooping to the shore, and suspending themselves to the cliffs by the claw-bearing fingers of their wing-limbs.

Tortoises were the boatmen of the Cretaceous waters of the eastern coast, but none had been known from the deposits of Kansas until very recently. But two species are on record; one large and strange enough to excite the attention of naturalists is the *Protostega gigas*, Cope. It is well known that the house or boat of the tortoise or turtle is formed by the expansion of the usual bones of the skeleton till they meet and unite, and thus become continuous. Thus the lower shell is formed of united ribs of the breast and of the breast-bone, with bone deposited in the skin. In the same way the roof is formed by the union of the ribs with bone deposited in the skin. In the very young tortoise the ribs are separate as in other animals; as they grow older they begin to expand at the upper side of the upper end, and with increased age the expansion extends throughout the length. The ribs first come in contact, where the process commences, and, in the land-tortoise, they are united to the end. In the sea-turtle, the union ceases a little above the ends. The fragments of the *Protostega* were seen by one of my party projecting from a ledge of a low bluff. Their thinness and the distance to which they were traced excited my curiosity, and I straightway attacked the bank with the pick. After several square feet of rock had been removed, we cleared up one floor, and found ourselves well repaid. Many long slender pieces of two inches in width lay upon the ledge. They were evidently ribs, with the usual heads, but behind each head was a plate like the flattened bowl of a huge spoon, placed crosswise. Beneath these stretched two broad plates, two feet in width, and no thicker than binder's board. The edges were fingered, and the surface hard and smooth. All this was quite new among full-grown animals, and we at once determined that more ground must be explored for further light. After picking away the bank, and carving the soft rock, new masses of strange bones were disclosed. Some bones of a large paddle were recognized, and a leg-bone. The shoulder-blade of a huge tortoise came next, and further examination showed that we had stumbled on the burial-place of the largest species of sea-turtle yet known. The single bones of the paddle were eight inches long, giving the spread of the expanded flippers as considerably over fifteen feet. But the ribs were those of an ordinary turtle just born, and the great plates represented the bony deposit in the skin, which, commencing independently in modern turtles, united with each other below at an early day. But it was incredible that the largest of known turtles

should be but just hatched, and for this and other reasons it has been concluded that this "ancient mariner" is one of those forms not uncommon in old days, whose incompleteness in some respects points to the truth of the belief that animals have assumed their modern perfections by a process of growth from more simple beginnings.

The Cretaceous ocean of the West was no less remarkable for its fishes than for its reptiles. Sharks do not seem to have been so common as in the old Atlantic, but it swarmed with large predaceous forms related to the salmon and saury.

Vertebræ and other fragments of these species project from the worn limestone in many places. I will call attention to perhaps the most formidable as well as the most abundant of these. It is the one whose bones most frequently crowned knobs of shale, which had been left standing amid surrounding destruction. The density and hardness of the bones shed the rain off on either side, so that the radiating gutters and ravines finally isolated the rock mass from that surrounding. The head was as long or longer than that of a fully grown grizzly bear, and the jaws were deeper in proportion to their length. The muzzle was shorter and deeper than that of a bull-dog. The teeth were all sharp cylindric fangs, smooth and glistening, and of irregular size. At certain distances in each jaw they projected three inches above the gum, and were sunk one inch into the jaw margin, being thus as long as the fangs of a tiger, but more slender. Two such fangs crossed each other on each side of the middle of the front. This fish is known as *Portheus molossus*, Cope. Besides the smaller fishes, the reptiles no doubt supplied the demands of his appetite.

The ocean in which flourished this abundant and vigorous life, was at last completely inclosed on the west by elevations of sea-bottom, so that it only communicated with the Atlantic and Pacific at the Gulf of Mexico and the Arctic Sea. The continued elevation of both eastern and western shores contracted its area, and when ridges of the sea-bottom reached the surface, forming long, low bars, parts of the water-area were inclosed and connection with salt-water prevented. Thus were the living beings imprisoned and subjected to many new risks to life. The stronger could more readily capture the weaker, while the fishes would gradually perish through the constant freshening of the water. With the death of any considerable class the balance of food-supply would be lost, and many larger species would disappear from the scene. The most omnivorous and enduring would longest resist the approach of starvation, but would finally yield to inexorable fate; the last one caught by the shifting bottom among shallow pools, from which his exhausted energies could not extricate him.

PART II.—GEOLOGY.

The geology of this region has been very partially explored, but appears to be quite simple. The following description of the section along the line of the Kansas Pacific Railroad will probably apply to similar sections north and south of it. The formations referable to the Cretaceous period on this line are those called by Messrs. Meek and Hayden the Dakota, Benton, and Niobrara groups, or Nos. 1, 2, and 3. According to Leconte,* at Salina, one hundred and eighty-five miles west of the State line of Missouri, the rocks of the Dakota group constitute

* Notes on the Geology of the Survey for the Extension of the Union Pacific Road, Eastern Division, from the Smoky Hill to the Rio Grande. By John L. Leconte, M. D., Philadelphia, 1868.

the bluffs, and continue to do so as far as Fort Harker, thirty-three miles farther west. They are "a coarse, brown sandstone, containing irregular concretions of oxide of iron," and numerous mollusks of marine origin. Near Fort Harker certain strata contain large quantities of the remains (leaves chiefly) of dicotyledonous and other forms of land vegetation. Near this point, according to the same authority, the sandstone beds are covered with clay and limestone. These he does not identify, but portions of it from Bunker Hill, thirty-four miles west, have been identified by Dr. Hayden as belonging to the Benton or second group. The specimen consisted of a block of dark bluish-gray clay rock, which bore the remains of the fish *Apsopelix sauriformis*, Cope. That the eastern boundary of this bed is very sinuous is rendered probable by its occurrence at Brookville, eighteen miles to the eastward of Fort Harker, on the railroad. In sinking a well at this point, the same soft, bluish clay rock was traversed, and at a depth of about 30 feet the skeleton of a saurian of the crocodilian order was encountered, the *Hyposaurus Vebbii*, Cope.

The boundary line or first appearance of the beds of the Niobrara division has not been pointed out, but at Fort Hays, seventy miles west of Fort Harker, its rocks form the bluffs and outcrops everywhere. From Fort Hays to Fort Wallace, near the western boundary of the State, one hundred and thirty-four miles beyond, the strata present a tolerably uniform appearance. They consist of two portions—a lower of dark bluish calcareo-argillaceous character, often thin-bedded; and a superior, of yellow and whitish chalk, much more heavily bedded. Near Fort Hays the best section may be seen at a point eighteen miles north, on the Saline River. Here the bluffs rise to a height of 200 feet, the yellow strata constituting the upper half. No fossils were observed in the blue bed; but some moderate-sized *Ostreæ*, frequently broken, were not rare in the yellow. Half-way between this point and the fort, my friend N. Daniels, of Hays, guided me to a denuded tract covered with the remains of huge shells described by Mr. Conrad, at the close of this section, under the names of *Haploscapha grandis* and *H. eccentrica*. They may have affinities to the *Rudistes;* some of them are 27 inches in diameter. They exhibited concentric obtuse ridges on the interior side, and one species a large crest behind the hinge. Fragments of fish vertebræ of the *Anogmius* type were also found here by Dr. Janeway. These were exposed in the yellow bed. Several miles east of the post, Dr. J. H. Janeway, post-surgeon, pointed out to me an immense accumulation of *Inoceramus problematicus* in the blue stratum. This species also occurred in abundance in the bluffs west of the fort, which were composed of the blue bed, capped by a thinner layer of the yellow. Large globular or compound globular argillaceous concretions coated with gypsum were abundant at this point.

Along the Smoky Hill River, thirty miles east of Fort Wallace, the south bank descends gradually, while the north bank is bluffy. This, with other indications, points to a gentle dip of the strata to the northwest. The yellow bed is thin or wanting on the north bank of the Smoky, and is not observable on the north fork of that river for twenty miles northward or to beyond Sheridan Station on the Kansas Pacific Railroad. Two isolated hills, "The Twin Buttes," at the latter point, are composed of the blue beds, here very shaly, to their summits. This is the general character of the rock along and north of the railroad between this point and Fort Wallace.

South of the river the yellow strata are more distinctly developed. Butte Creek Valley, fifteen to eighteen miles to the south, is margined

by bluffs of from 20 to 150 feet in height on its southern side, while the northern rises gradually into the prairie. These bluffs are of yellow chalk, except from ten to forty feet of blue rock at the base, although many of the cañons are excavated in the yellow rock exclusively. The bluffs of the upper portion of Butte Creek, Fox and Fossil Spring (five miles south) Cañons are of yellow chalk, and the reports of several persons stated that those of Beaver Creek, eight miles south of Fossil Spring, are exclusively of this material. Those near the mouth of Beaver Creek, on the Smoky, are of considerable height, and appear, at a distance, to be of the same yellow chalk.

I found these two strata to be about equally fossiliferous, and am unable to establish any paleontological difference between them. They pass into each other by gradations in some places, and occasionally present slight laminar alternations at their line of junction. I have specimens of *Cimolichthys semianceps*, Cope, from both the blue and yellow beds, and vertebræ of the *Liodon glandiferus*, Cope, were found in both. The large fossil of *Liodon dyspelor*, Cope, was found at the junction of the beds, and the caudal portion was excavated from the blue stratum exclusively. Portions of it were brought east in blocks of this material, and these have become yellow and yellowish on many of the exposed surfaces. The matrix adherent to all the bones has become yellow. A second incomplete specimen, undistinguishable from this species, was taken from the yellow bed.

As to mineral contents, the yellow stratum is remarkably uniform in its character. The blue shale, on the contrary, frequently contains numerous concretions, and great abundance of thin layers of gypsum and crystals of the same. Near Sheridan, concretions and septaria are abundant. In some places the latter are of great size, and being imbedded in the stratum have suffered denudation of their contents, and the septa standing out form a huge honey-comb. This region, and the neighborhood of Eagle Tail, Colorado, are noted for the beauty of their gypsum crystals, the first abundantly found in the Cretaceous formation. These are hexagonal-radiate, each division being a pinnate or feather-shaped lamina of twin rows of crystals. The clearness of the mineral and the regular leaf and feather forms of the crystals give them much beauty. The bones of vertebrate fossils preserved in this bed are often much injured by the gypsum formation which covers their surface, and often penetrates them in every direction.

The yellow bed of the Niobrara group disappears to the southwest, west, and northwest of Fort Wallace beneath a sandy conglomerate of uncertain age. In color it is light, sometimes white; and the component pebbles are small and mostly of white quartz. The rock weathers irregularly into holes and fissures, and the soil covering it is generally thin and poor. It is readily detached in large masses, which roll down the bluffs. No traces of life were observed in it, but it is probably the eastern margin of the southern extension of the White River Miocene Tertiary stratum. This is at least indicated by Dr. Hayden in his geological preface to Leidy's Extinct Mammals of Dakota and Nebraska.

Economically the beds of the Niobrara formation possess little value except when burned as a fertilizer. The yellow chalk is too soft in many places for buildings of large size, but it will answer well for those of moderate size. It is rather harder at Fort Hays, as I had occasion to observe at their quarry. That quarried at Fort Wallace does not appear to harden by exposure; the walls of the hospital, noted by Leconte on his visit, remained in 1871 as soft as they were in 1867. A few worthless beds of bituminous shale were observed in Eastern Colorado.

The only traces of glacial action in the line explored were seen near Topeka. South of the town are several large, erratic masses of pink and bloody quartz, whose surfaces are so polished as to appear as though vitrified. They were transported, perhaps, from the Azoic area near Lake Superior.

PART III.—SYNOPSIS OF THE FAUNA.

REPTILIA.

1. FROM THE BENTON GROUP.

The only reptile yet indicated from this stratum in Kansas is the crododilian.

HYPOSAURUS VEBBII, Cope.—A species, of 8 or 10 feet in length, found in digging a well at Brookville, and presented to me by my friend Dr. Wm. E. Webb, of Topeka. The individual discovered was not fully grown, but indicates a smaller and stouter crocodile than the *H. rogersii*, Owen, of the New Jersey green-sand. This genus belongs to the group with subbiconcave vertebræ, and had a long, subcylindric snout.

2. FROM THE NIOBRARA BED.

Twenty-three species constitute what is known of the Cretaceous reptilian fauna of this area. These have been discovered in large part by exploring expeditions conducted by Professor Mudge, of the State Agricultural College of Kansas; by Professor O. C. Marsh, of Yale College; and by the writer.

These species represent four of the orders already known to exist in the Cretaceous beds of other parts of the United States. The writer first pointed out the existence of *Pythonomorpha* and *Sauropterygia*, and subsequently discovered *Testudinata*. Professor Marsh has added to these the *Ornithosauria*. The first named of these orders is by far the most abundant, the relative number of species being as follows: *Pythonomorpha*, 17; *Sauropterygia*, 2; *Testudinata*, 2; *Ornithosauria*, 2.

The first-named order includes species formerly referred to the *Lacertilia*, or lizards proper, but the structures of the posterior region of the cranium, of the pelvic arch, and of the limbs, indicate that they constitute a well-marked division. The cranium mingles lizard and serpent characters; the pelvis is entirely peculiar, while the limbs are somewhat like those of *Plesiosaurus* and turtles. In form they were exceedingly elongate and snake-like, with eel-like, flattened tail of great length, two pairs of flippers, a short neck, and very long, acute, flat head, with the eyes opening upwards.

In the *Sauropterygians* the proportions were reversed, the neck being, in the two known Kansas species, excessively elongate, and the tail rather less so. The two pairs of flippers were elongate and powerful, and the head was light and rather small, as would be appropriate to its position at the extremity of so long a neck.

The *Testudinata*, or turtles, are well known in their general appearance. Those yet known from Kansas are, however, very peculiar. The *Cynocercus* had a long, slender tail, while the *Protostega* had no shell, properly so called. In other words, the ribs remained distinct, as in the young of existing sea-turtles, or as in the adult *Sphargis*, but large, bony shields were developed in the skin.

The *Ornithosauria* are the flying reptiles, which share with their reptilian features some characters of birds. Two species of considerable

size has left abundant but crushed fragments in the yellow chalk of the Niobrara formation. One species must have measured nearly 25 feet across the wings. The giants of this sea were the *Liodon proriger*, Cope; L. *dyspelor*, Cope; *Polycotylus latipinnis*, Cope; and *Elasmosaurus platyurus*, Cope. Of these the first was apparently the most abundant. The second was the most elongate, exceeding in length perhaps any other known reptile. The last named had the most massive body, and exhibited an extraordinary appearance in consequence of the great length of its neck.

ORDER I.—PYTHONOMORPHA, Cope.

Trans. Amer. Philos. Soc., 1868; Proc. Am. Phil. Soc., 1871, December.

The material obtained during the autumn of 1871 by the writer proves conclusively that this order of reptiles attained a predominant importance during the Niobrara epoch of the Cretaceous period. This is indicated by the great profusion of individual remains and specific forms. Although occurring in America wherever the Cretaceous formation appears, they are so far more numerously represented in Kansas than elsewhere. Though not rare in New Jersey, crocodiles and tortoises outnumber them; but in Kansas all other orders are subordinate to the *Pythonomorpha*. As is now well known since 1868,* the seas of the American continent were the home of this order, while they were comparatively rare in those of Europe. In the latter country we have four species only determined by paleontologists, viz:

Mosasaurus	2
Liodon	1
(?) Saurospondylus	1

In North America the species have been exactly determined from three regions, as follows:

Green-sand of New Jersey.

Mosasaurus	6
Baptosaurus	2
Clidastes	2
Liodon	4
(?) Diplotomodon	1
	15

Rotten limestone, Alabama.

Mosasaurus	1
Holcodus	1
Liodon	3
Clidastes	2
	7

* See Trans. Amer. Philos. Soc., Vol. XIV.

Chalk of Kansas.

Clidastes	3
Edestosaurus	4
Holcodus	4
Liodon	6
	17

We have additional species from—

North Carolina, (Mosasaurus)	1
Mississippi, (Platecarpus)	1
Nebraska, (Mosasaurus)	1

Making, with the others from—

New Jersey	15
Alabama	7
Kansas	17
A total of	42

Of these I am not acquainted with any which extends its range into any two of the areas above named, while some of these districts possess peculiar genera. It is, nevertheless, premature to draw any conclusions as to geographical range, as most of the species are known from but few specimens as yet.

The present investigations have added some points of importance to the history of the structure of the order.

First, as to the pterygoid bones. It appears that these elements are thin plates, having a free laminar termination, and are entirely toothless. They articulate with the palatines by a process which fits the posterior emargination of the latter. In the *Edestosaurus tortor* they are about half the length of the palatines. They present no indications of ectopterygoid. The bones named by authors pterygoids, in imitation of Cuvier, are elongate palatines, and the external process extending to the maxillary is that seen in *Varani*, *serpents*, &c., and is at no time distinct from the palatines.

Secondly, as to the parieto-squamosal arch, which is well developed. It is preserved in *Holcodus ictericus* and *Liodon curtirostris* in its parietal part, and *H. coryphœus* in the squamosal part. It was quite strong in the species named.

Thirdly, as to the pelvis. This part, which has been observed by Marsh in *Edestosaurus dispar*, is unusually perfect in *Liodon dyspelor*. The pubes are the only elements united below, forming a weak support to the abdomen. The ilia are slender, not united with the vertebral processes above, or without indications of such contact. The ischia are the most slender and directed backward. The peculiarities of the pelvis add to the broad distinction between this order and the *Lacertilia*.

Fourthly, in the hind limb. The femur of *L. crassartus* has been described by the writer, and Professor Marsh asserts its existence in *Liodon*, *Clidastes*, and *Edestosaurus*. The present collection exhibits both femur, tibia and fibula of *L. dyspelor*, and these elements are now first described. The first mentioned is not larger, sometimes smaller, than the humerus, and has a prominent trochanter, nearly connected with the head. The shaft is not curved, and the distal end is expanded.

The tibia is a narrow bone, expanded at both ends; the fibula is like that of *Plesiosaurus*, but wider, or partly discoid. It has been known to naturalists, but not determined. Thus, I figured it for *Liodon lævis*,* and Leidy figured it for an Upper Mississippi species.†

There was for a considerable time doubt as to the structure of the anterior limbs in this order, some authors asserting their ambulatory, others their natatory character. Dr. Leidy inferred that they were flippers, after an examination of a humerus from Mississippi. This turns out to belong to a turtle, (*Protostega tuberosa*, Cope;) hence the first real determination of the character of these members was made by the writer in his description of the four limbs of *Clidastes propython*, the first species in which they were well represented by specimens.

CLIDASTES, Cope.

Proc. Acad. Nat. Sci., Phila., 1868, p. 233; Trans. Amer. Philos. Soc., 1870, p. 211.

Vertebræ with the zygosphen articulation. [Palatine bones flat and alate; the teeth not exposed at their bases unequally. This point has not been observed in the type species *C. iguanavus*.]

CLIDASTES CINERIARUM, Cope, (Proc. Amer. Philos. Soc., 1870, 583.)—Two individuals from different points near the North Fork of the Smoky Hill River, Kansas.

The largest species of the genus.

CLIDASTES VYMANII, Marsh, (Amer. Jour. Sci. and Arts, June, 1871.)—From two individuals from the Smoky Hill River and its North Fork. A small species.

CLIDASTES PUMILUS, Marsh, (*loc. cit.*)—From one individual from the Smoky Hill River. The smallest known *Mosasauroid*, according to Professor Marsh, reaching a length of only 12 feet.

EDESTOSAURUS, Marsh.

Amer. Jour. Sci. and Arts, 1871, June.

Vertebræ with the zygosphen articulation; palatine bones narrow, partly vertical; the bases of the pterygoid teeth exposed on one side, or pleurodont. (It is uncertain whether the type of *Clidastes* presents this structure or not.)

EDESTOSAURUS TORTOR, Cope, (Proc. Amer. Philos. Soc., 1871, December.)—A slender species of some 30 feet in length, with a narrow, pointed head of 2½ feet. Its teeth are compressed, and with a cutting edge fore and aft, and were 18 in number on the under jaw; the palate was armed with 11 teeth.

Found near Fossil Spring.

EDESTOSAURUS STENOPS, Cope, (*loc. cit.*)—A species not unlike the last, founded on one individual of rather heavier proportions. Its prominent character is the narrowness of the face in front of the orbits, the prefrontal bones being nearly vertical instead of horizontal.

From Fossil Spring.

EDESTOSAURUS DISPAR, Marsh, (Amer. Jour. Sci. and Arts, June, 1871.)—Smoky Hill River.

EDESTOSAURUS VELOX, Marsh, (*loc. cit.*)—Near the North Fork of the Smoky Hill River.

* Trans. Amer. Philos. Soc., 1869, p. 205.
† Cretaceous Reptiles U. S., Tab. VIII, Fig. 10.

HOLCODUS, Gibbes, (Cope emend.)

Vertebræ without the zygosphen articulation. Palatine bones flat, horizontal alate; its teeth not unequally exposed at the bases, or not pleurodont. This genus bears the same relation as regards the palatine bones and teeth to the genus *Liodon* that *Clidastes* does to *Edestosaurus*.

HOLCODUS CORYPHÆUS, Cope, (Proc. Amer. Philos. Soc., 1871, December.)—A stouter species than the *Edestosauri* above noticed, with an elevated occipital crest, rising vertically from the occipital condyle. The upper jaw supports thirteen sharp, curved teeth, of which two are in the premaxillary bone. Palatine teeth, 12. Length, 30 feet.

Found on Fossil Spring Cañon.

HOLCODUS TECTULUS, Cope, (*loc. cit.*)—A smaller species than the last, with the cervical vertebræ flattened, and all the vertebræ with a rudiment of the additional articulation found in *Clidastes*. Length, about 20 feet. Quadrate bone as in *H. mudgei*.

From Butte Creek.

HOLCODUS ICTERICUS, Cope, *Liodon ictericus*, Cope, (Proc. Amer. Philos. Soc., 1870, p. 577;) (Hayden's Geological Survey of Wyoming and Adjoining Territories, 1871.)—In addition to the two individuals of tnis species procured by Professor B. F. Mudge, in one of his geological surveys, the writer obtained a considerable part of a third from a low bluff on Fox Cañon, south of Fort Wallace. It is a species of about the size of the *H. coryphæus*, and has a rather short head. It lacks the rudimental zygosphene so prominent in *H. coryphæus* and *H. tectulus*.

HOLCODUS MUDGEI, Cope; *Liodon mudgei*, Cope, (Proc. Am. Philos. Soc., 1870, 581; Hayden's Survey Wyoming, &c., 1871, p. —.) A specimen was obtained by Prof. Mudge, on the Smoky Hill River, jaws and with teeth were found on Fox Cañon by the writer. The characters distinguishing it are the following: Vertebræ without rudimental zygosphen; quadrate bones with plane surfaces from the proximal articular surface and the external obtuse-angled ridge to the meatal pit, the latter therefore not sunk in a depression as the other species.

LIODON, Owen, (Cope emend.)

Trans. Amer. Philos. Soc., 1870, p. 200.

Vertebræ without zygosphen and zygantrum. Palatine bones vertical, separated from each other, narrowed; the teeth more or less pleurodont. Chevron-bones articulated freely with the caudal vertebræ.

This genus embraces several species from the Kansas chalk, which vary in size from that most usual in the last genus to the largest known in the order.

LIODON CURTIROSTRIS, Cope, (Proc. Amer. Philos. Soc., 1871, December.)—The specimen above described was found by the writer on the denuded foot of a bluff on the lower part of Fossil Spring Cañon. The posterior part of the cranium, with several vertebræ, were found exposed, and many other bones, including the cranium, were found only covered by the superficial wasted material. Other portions were exposed on excavating the blue-gray bed of the side of the spur adjoining. The name has reference to the abbreviation of the head and jaws. These are relatively shorter than in any other species here described where these parts are known. The end of the muzzle does not overhang, but descends gradually to the tooth-line. There are but 10 maxillary teeth

and 2 premaxillaries on each side. Size about that of *H. coryphæus*, or near 30 feet in length.

LIODON GLANDIFERUS, Cope, (*loc. cit.*)—A larger species than the last, with apparently a greater flexibility of body, as indicated by the forms of the vertebral centra. It is represented by portions of two individuals from localities twenty-five miles apart. There are unfortunately in each case only a cervical vertebra, but they agree in possessing such peculiarities as distinguish them widely from anything yet known to the writer.

LIODON LATISPINUS, Cope, (Proc. Am. Philos. Soc., 1871, p. 169; *loc. cit.*, 1871, December.)—The remains representing this species consist of seven cervical and dorsal vertebræ, five of them being continuous and inclosed in a clay concretion. It is a large species, nearly equaling the *L. mitchillii* in its dimensions; that is, 40 or 50 feet in length, and is intermediate between such gigantic forms as *L. dyspelor* and the lesser *L. curtirostris*. The type specimens were found by Professor B. F. Mudge, one mile southwest of Sheridan, near the "Gypsum Buttes."

LIODON CRASSARTUS, Cope, sp. nov.; *Liodon, large species near L. proriger*, Cope, (Proc. Amer. Philos. Soc., 1871, p. 168.)—This saurian, which is similar in size to the last, is represented by a series of dorsal, lumbar, and caudal vertebræ, with some bones of the limbs.

The vertebræ are as much distinguished for their shortness as those of *L. latispinus* are for their elongation. The articular faces are but little broader than deep, and their axes are slightly oblique. This species is interesting as having furnished the materials for the first description of the posterior extremities in this order of reptiles. The humerus is a remarkable bone, having the outline of that of *Clidastes propython*, Cope, but is very much stouter, the antero-posterior dimensions of the proximal extremity being greatly enlarged. The long diameters of the two extremities are, in fact, nearly at right angles instead of in the same plane, and the outline of the proximal is subtriangular, one of the angles being prolonged into a strong deltoid crest on the outer face of the bone, which extends half its length. The inner or posterior distal angle is much produced, while the distal extremity is a flat, slightly curved, diamond-shaped surface. The fibula is as broad as long and three-quarters of a disk. The phalanges are stout, thick, and depressed, thus differing much from those of *Liodon ictericus*. A bone which I cannot assign to any other position than that of femur, has a peculiar form. It is a stout bone, but more slender than the humerus. The shaft is contracted and subtrilateral in section. The extremities are flattened, expanded in directions transverse to each other; the proximal having, however, a lesser expansion in the plane of the distal end. The former has, therefore, the form of an equilateral spherical triangle, the apex inclosing a lateral fossa and representing probably the great trochanter. The distal extremity is a transverse and convex oval. This bone is either ulna, femur, or tibia, judging by form alone. Its greater length, as compared with the fibula, forbids its reference to the last; the trochanter-like process of the head is exceedingly unlike any examples of the second bone I have seen. Its reference to femur is confirmed by its presence with the caudal vertebræ of a similar species from near the Missouri River, Nebraska, and its resemblance to the femur of *L. dyspelor*.

The remains above described were obtained by Professor B. F. Mudge, near Eagle Tail, in Colorado, a few miles west of the line separating that Territory from the State of Kansas.

A series of twenty-nine caudal vertebræ, with and without diapophyses, from a bluff on Butte Creek, belongs perhaps to this species. The proximal specimens, at least, cannot be distinguished from those of Pro-

fessor Mudge's collection. The distal ones cannot readily be distinguished from those of *L. proriger*.

LIODON PRORIGER, Cope, (Proc. Acad. Nat. Sci., 1869, 123, Trans. Amer. Philos. Soc., 1870, 202.)—This is the most abundant of the large species of the Kansas chalk. The writer found a muzzle consisting of premaxillary and portions of maxillary and dentary bones in a spur of the lower bluffs of Butte Creek, and numerous fragments of cranium and vertebræ on a denuded tract in the same neighborhood. Both of these belonged to individuals of smaller size than the type, the opportunity of examining which I owe to Professor Agassiz. The more complete Butte Creek specimen belongs to a huge animal; the size is grandly displayed by a complete premaxillary bone, with its projecting snout, and large fragments of the maxillary. These furnish characters confirmatory of those already given as above. The vertebræ are remarkable examples of flattening under pressure, without fracture, some of them having a vertical diameter no greater than one's hand. The cervicals are less flattened, and give the impression that they were not transversely elliptic. This is consistent with our knowledge of the perfect specimen, where it is, as described, furnished with vertically ovate articular surfaces. In this the cup is symmetrical and not distorted, but the ball is a little compressed by pressure.

The most important addition to the knowledge of this species, furnished by the Butte Creek specimen, is the character of the quadrate bone. A portion of the palatine bone, supporting these teeth, displays the characters of the type, viz, the inner face vertical and deeper than the outer, and forming a strong parapet of bone on the superior or toothless aspect; the outer face a little expanded laterally; the bases of the teeth exposed. It is proper to add that the locality ascribed to the type specimen, "near Fort Hays, Kansas," which was given me, on inquiry, is probably erroneous, Fort Wallace being the point intended.

LIODON DYSPELOR, Cope, (Proc. Amer. Philos. Soc., 1870, 574; 1871, 168, 172.)—This large reptile was first described from specimens sent to the Smithsonian Institution from New Mexico. Professor Mudge subsequently obtained it in Kansas, and on my late expedition I had the good fortune to procure a large portion of another, on a sloping bluff on Butte Creek, fourteen miles south of Fort Wallace. This specimen is one of the most instructive which has yet been discovered, including, as it does, fifty vertebræ from all parts of the column, a large part of the cranium, with teeth, and both quadrate bones; the scapular arch complete, except back of coracoid on one side; both humeri, radius, and numerous phalanges of fore limb; the pelvic arch complete, with one hind limb complete to tarsus, with phalanges. The premaxillary is wanting, but the adjacent suture of the maxillary remains.

Measurements.—Estimated length of cranium, 5 feet, 1.570 metres; estimated total length, 75 feet.

This specimen does not appear to be quite as large as the type, which came from Fort McRae, New Mexico. The diameters of the vertebral centra appear to be larger, in proportion to the length of the cranium, than in the *Mosasaurus dekayi;* hence, probably, the body had a greater diameter. In estimating its length, reference is had to the relations in size of the caudal vertebræ of the type of *L. proriger*, and to the caudal series of a small *Liodon* found on the bluffs of Butte Creek. The caudal vertebræ are quite similar to those of the former; in the latter a series of thirty centra exhibit very little diminution in size. On such a basis the length would be about seventy-five feet.

Portions of a second individual of this species, or of *L. proriger*, were found on the Fox Cañon. They belonged to a larger animal, one equal to the New Mexican first described. Professor Mudge has fragments of still larger specimens.

The principal specimen above described was excavated from a chalk bluff. Fragments of the jaws were seen lying on the slope and other portions entered the shale. On being followed, a part of the cranium was taken from beneath the roots of a bush, and the vertebræ and limb-bones were found further in. The vertebral series extended parallel with the outcrop of the beds, and finally turned into the hill, and was followed so far as time would permit. It was abandoned at the anterior caudal vertebræ for more favorable circumstances or a more persevering excavator.

The outcrop of the stratum was light yellow. The concealed part of the bed was bluish. Yellow chalk left on the specimens in thin layers became a white or nearly so. The yellow and blue strata are definitely related in most localities, the former being the superior, but in others they passed into each other on the same horizon.

TESTUDINATA.

PROTOSTEGA, Cope.

Proc. Amer. Phil. Soc., 1871, p. 173; *loc. cit.*, March, 1872.

This genus is the type of a new family of tortoises of the suborder *Athecæ*, characterized by the lack of expansion of the ribs into a bony roof or carapace, and the development of dermal bones only on the upper surfaces. The dermal bones consist of large plates lying above the ribs, which have no sutural union with each other; of small vertebral shields on the dorsal line, and of thin, marginal bones, which have no sutural union with each other or with the other bones. The vertebræ preserved possess ball-and-socket joints, and have flat neural arches, with widely spreading articular processes. The humeri are flat, and furnished with an enormous deltoid crest. The fore limbs were very long, and formed flippers like those of the marine turtles of the present seas. The bones of the head were very light and thin, and mostly united by squamosal or overlapping sutures. The mandible presented the elements usual in the marine turtles, and had no angle. It exhibits a deep pterygoid fossa, and is very light. The constitution of the bones is rather dense, and there are no medullary cavities whatever. The superficial layer is very thin and striate. The bones are all very fragile. The fore limb discovered several years since in the Cretaceous of Mississippi, near to Columbus, with vertebræ and teeth, of *Platecarpus tympaniticus*, which was referred by Dr. Leidy to that species, probably belongs to *Protostega*. It represents a species distinct from the *P. gigas*, which may be called *Protostega tuberosa*, Cope, and differs from *P. gigas* in the more elongate form of the humerus, with superior position and more enlarged form of the bicipital process. The large deltoid crest appears to be also much more prolonged. A third species, or allied genus, has also been discovered in the green-sand of New Jersey. It is represented by a fragment of a gigantic humerus, which was rightly regarded as pertaining to a turtle; though he never described it, Dr. Leidy figured it,* and referred "to the gigantic *Mosasaurus*."† I refer it provisionally to *Protostega* with the name *P. neptunia*. The humerus

* Cretaceous Reptiles of North America, Tab. VII, Fig. 4. † *Loc. cit.*, p. 43.

differs from those of the two preceding species in having a much more slender shaft. The *Pneumatarthrus peloreus*, Cope, established on vertebræ, may be an ally.

PROTOSTEGA GIGAS, Cope.—This fossil includes many parts of the endo- and exoskeleton. The bones of the former have a radiating ossification, which terminates in many cases in digitations of their margins. These margins, especially of the vertebral and marginal bones, are exceedingly attenuated, not being thicker than paper. The vertebral has an obtuse median keel. The marginals have no inferior lamina and receive the extremity of the rib. The ribs have a wide, radiate, lined expansion, extending from the position of the tubercle round and beyond the head. The phalanges are long and flat, and the extent of the fore-limbs could have been little or nothing short of fifteen feet. Found near Butte Creek, Southwest Kansas.

CYNOCERCUS, Cope.

Proc. Amer. Philos. Soc., 1872, January.

Established on metatarsal and caudal vertebræ of a tortoise of uncertain, but in any case peculiar affinities. The caudal vertebræ are not anterior ones, almost lacking diapophyses, but are long and slender, and the articular faces singularly incised. The form had a tail more elongate than the snapping tortoise, and different from it in details of composition.

CYNOCERCUS INCISUS, Cope, (*loc. cit.*)—A species about the size of the Mississippi snapper, *Macrochelys lacertina*, from near Butte Creek.

SAUROPTERYGIA.

POLYCOTYLUS, Cope.

Trans. Amer. Philos. Soc., 1869, 34; Hayden's Rept. Survey, Wyoming, 1871, 386.

As a detailed account of this genus has been already given in the report on the Geology of Wyoming, *loc. cit.*, I will not repeat it here. From this the characters which separate this genus from *Plesiosaurus* may be derived, as follows:

First. The deeply biconcave and very stout vertebral centra.

Secondly. The tibia broader than long, resembling those of *Icthyosaurus*.

Thirdly. The coalescence and depression of the cervicals.

Fourthly. The continuity of the neural arches.

Fifthly. The continuity of the diapophyses of the caudals.

POLYCOTYLUS LATIPINNIS, Cope, (*loc. cit.*, p. 36, Pl. I, Figs. 1–13.)—The powerful extremital pieces indicate a body to be propelled of not less than usual proportions. If this be the case, the number of dorsal vertebræ is considerably greater than in the species of this order in general, and approaching more the *Icthyosauri*. I do not intend to suggest any affinity between the latter and the present genus, as none exists. What the extent of cervical vertebræ may have been is uncertain. The caudals have probably been numerous, though not probably so extended as in *Elasmosaurus*. The size of the species can be approximately estimated from the proportions furnished by Owen (Reptiles of the Liassic Formations) for *Plesiosaurus rostratus*. The skeleton of this species measures 11 feet 8 inches, and the dorsal vertebræ are of less vertical and equal transverse diameter compared with those of the

present saurian. We may therefore suppose that the latter exceeded the former in dimensions. Should the humerus have been related to the fore limb, as in *Plesiosaurus dolichodirus*, Conyb., the latter would have had a length of 4 feet 3 inches; as the proportions of the radius and phalanges are shorter, the limb was probably relatively shorter. If related to the total length, as in the same *Plesiosaurus*, the humerus would indicate a length of 17½ feet. As the cervical vertebræ become attenuated, as compared with the dorsals to a greater degree in *Polycotylus* than in *Plesiosaurus*, I have little doubt that the length of this species exceeded that amount.

William E. Webb, of Topeka, discovered the specimens from which this species was first described, and liberally forwarded them to me for examination and description. Other specimens have been discovered since that time by various other persons. I have received numerous fragments of an individual of about the size of the one above described, which were found by Professor B. F. Mudge, at a point near the mouth of the north branch of the Smoky Hill River.

ELASMOSAURUS, Cope.

Leconte's Notes on Geology of the Route of the Union Pacific Railroad, 1868, p. 68; Cope, Proc. Acad. Nat. Sci., 1868, p. 92; Trans. Amer. Philos. Soc., 1869, p. 44.

This genus has been more completely preserved to us than any other American representative of the order, and hence may be accepted as most clearly expressive of its characters. In the interpretation of these, however, considerable difficulty has been experienced, as the structure form appears, at first sight, to reverse to a remarkable degree the usual proportions of known reptiles. No portions of limbs were, however, found with the vertebræ. The skeleton so nearly complete would indicate no violent disturbance of the carcass; but if there were, it would be an unusual accident that all of the four limbs should have been removed from their sockets without leaving even fragments.

This genus is well distinguished from *Plesiosaurus* by the peculiarity of the scapular arch. The mesosternum appears to be co-ossified with the claviculi, and the three elements form a broad breast-plate. If the claviculus was ever united with the scapula, as in *Plesiosaurus*, no evidence of it can be seen in the specimen. Both the clavicular and mesosternal elements are broader and more extended anteriorly.

Elasmosaurus platyurus, Cope, (Leconte's Notes, *loc. cit.* Proc. Acad. Nat. Sci., 1868, *loc. cit.*, 92.) *Discosaurus carinatus*, Cope, (Leconte's Notes, *loc. cit.*)—This, after *Mosasaurus*, the most elongate of the sea-saurians yet discovered, is represented by a more than usually complete skeleton in the museum of the Academy of Natural Sciences in Philadelphia. It was found by Dr. Theophilus H. Turner, the physician of the garrison at Fort Wallace, a point situated near the boundary-line separating Kansas from Colorado, a few miles north from the Smoky Hill Fork of the Kansas River. Portions of two vertebræ, presented by him to Dr. Leconte when on his geological tour in the interest of the United States Pacific Railroad Company, were brought by the latter gentleman to the academy, and indicated to the writer the existence of an unknown plesiosauroid reptile. Subsequent correspondence with Dr. Turner resulted in his employing a number of men, who engaged in excavations, and succeeded in obtaining a large part of the monster. Its vertebræ, one hundred and twelve in number, were found to be almost continuous, except a vacancy of some four feet in the anterior dorsal region. They formed a curved line, a considerable part of whose

convexity was visible on the side of a bluff of clay-shale rock, with seams and crystals of gypsum. The bones were all coated with a thin layer of gypsum, and in some places their dense layer had been destroyed by conversion into sulphate of lime.

The habit of this species, like that of its nearest known allies, was raptorial, as evinced by its numerous canine-like teeth and the fish-remains taken from beneath its vertebræ.

The general form of this reptile, whether it was furnished with large posterior limbs or not, was that of a serpent, with a relatively shorter, more robust, and more posteriorly placed body than is characteristic of true serpents, and with two pairs of limbs or paddles. It progressed by the strokes of its paddles, assisted by its powerful tail. The body was steadied by the elevated keel of the median dorsal line, formed by the broad, high neural spines. The snake-like neck was raised high in the air, or depressed, at the will of the animal; now arched swan-like preparatory to a plunge after a fish, now stretched in repose on the water or deflexed in exploring the depths below.

Localities. This species has been found in various parts of Kansas, besides that whence the specimen above described was procured. Professor B. F. Mudge obtained vertebræ from a point thirty miles east of Fort Wallace, which probably belong to this animal.

ORNITHOSAURIA.

ORNITHOCHIRUS, Seeley.

This genus embraces the largest of the pterodactyles or flying saurians. Besides a great expanse of wings, they had strong claw-bearing digitis in front, and a short tail. Their heads were slender and the teeth indicate carnivorous habits. Two species were found by the writer in Kansas.

ORNITHOCHIRUS UMBROSUS, Cope, (Proc. Amer. Philos. Soc., March, 1872.)—One of the largest known species, having an expanse of wing of nearly twenty-five feet.

ORNITHOCHIRUS HARPYIA, Cope, (*loc. cit.*)—A large species, but smaller than the last, with a wing expanse of eighteen feet. This species was abundant, and may be the one originally mentioned by Professor Marsh under the preoccupied name of *Pterodactylus owenii.*

PISCES.

Large numbers of remains of fishes are found in the Niobrara chalk. They are referable to three families and twenty-three species of physostomous or soft-rayed fishes, with the addition of a few sharks. The former were chiefly related to the salmon and to the pike, but were more strongly armed for offense and defense than their recent representatives.

SAURODONTIDÆ, Cope.

Proc. Amer. Philos. Soc., 1870, p. 529; Hayden's Survey Wyoming, &c., 1871, p. 414.; Proc. Amer. Philos. Soc., 1872, February.

A considerable accession of material belonging to several species of this family, furnishes important additions to our knowledge of their structure, and enables me to determine their affinities with more precision than heretofore. The results are of value to the student of com-

parative anatomy, and also to the paleontologist, as they appear to have been the predominant type of marine fishes during the Cretaceous period in the North American seas, and to have been abundant in those of Europe.

The characters already assigned to the family are confirmed by the new species discovered, and many additional ones added, as follows:

The cranial structure cannot be fully made out, but the following points may be regarded as ascertained. The *brain-case* is not continued between the orbits, and the *basis cranii* is double and with the muscular tube open. A large cavity is inclosed by the proötic, the pterotic, the opisthotic, &c. There are no exoccipital condyles, and that of the basioccipital is a conic cup. The pterotic and post-frontal are well developed. The ethmoid is well developed and slightly narrowed at its anterior extremity. The parasphenoid is narrowed and elongate; the vomer is continuous with it and is slightly expanded and then contracted at the anterior extremity. Neither it nor the parasphenoid support teeth in any of the known genera.

The premaxillary bones are short, and form but a small portion of the upper jaw. The maxillary is elongate and simple. The hyomandibular is rather narrow and does not present an elongate support for the operculum. The symplectic is well developed, entering far into the inferior quadrate. The latter is a broad bone, large, in contact with the metapterygoid, which is itself a thin plate, not probably attaining the pterotic. The superior branchihyals are short rods.

The relations of the supraoccipital, parietals, frontals, &c., cannot yet be satisfactorily made out, owing to the obscurity of the sutures. Nevertheless, the following points may be regarded as probably reliable. The frontals have a rather broad union with the ethmoid, and are separated by suture throughout their length. They do not extend much posterior to the orbits, and are succeeded by a rather narrow pair of bones, which extend to above the *foramen magnum*. These are not united by suture, but present thickened, smooth edges to each other, and appear, therefore, to have been separated by a fontanelle. Each is separated from a broad, lateral bone by a serrate suture, which is, perhaps, the pterotic, and certainly includes that element, as it supports the hyomandibular. It is not easy to determine what relation the median bones bear to the supraoccipital, but the structure looks a good deal like that characterizing the *Siluridæ*, or, considering the large pterotics, like the *Mormyridæ* plus the fontanelle. The shorter form of the pterotic in the *Characinidæ* and the *Catostomidæ* causes considerable difference in their appearance. There is no indication of fontanelle between the frontals in *Portheus*.

Portions of the scapula of *Portheus molossus* and other species are preserved. They have very stout articular surfaces, and, although not complete, have enclosed, more or less, a very large fontanelle. The superior surface is the larger, and is followed below by two others; the upper subvertical and small, the lower larger and transverse. These are surfaces supporting two basilar elements of the pectoral fin. There were, perhaps, three basilars; but the base of the coracoid displays no surface for articulation of a third.

The suture with the coracoid crosses immediately below the lower condyloid surface, and passes just below the scapular fontanelle, leaving in the specimens a fractured surface, which probably supported a præcoracoid. There are two fractured bases of the coracoid, which probably unite below, enclosing a foramen. On the scapulo-coracoid suture, just within the space between the two inferior condyles, is a smooth

hemispherical pit of considerable size. Just in front of it is another of crescentic form.

A partially complete circle of bone, convex on one side, concave on the other, was found with the remains of two species of *Portheus* and one of *Ichthyodectes.* They look like a sclerotic ossification, and as though molded on a globe. They are not segmented as in reptilian sclerotic ossifications, nor do they seem to have been completed circles.

The femoral bones, or those supporting the ventral fins, are preserved in *Ichthyodectes anaides* and a *Portheus*, best in the former. They are closely united posteriorly, the inner margin gradually approximating to the union, which is accomplished by the application of the subcylindric posterior part of the bones. In *Portheus* they are united by a coarse suture. There are no posterior processes, but the anterior are long and slender. Each is divided, the inner portion being rod-like, the exterior plate-like. The outer is probably the shorter; exteriorly it rises into an obtuse ridge on the lower side, and the plate then expands backward as well as outward, nearly inclosing a large sinus with the base of support of the fin. The fin-supporting surface is subround, with two exterior and one interior articular surfaces, and a projection in the middle, which has one or two articular faces of smaller size. The base of the anterior projections is rather broader in *Ichthyodectes* than in *Portheus.*

Three kinds of *spine-like rays* or supports of the fins have been found in connection with remains of species of this family, and the proper reference to their positions and species is as yet in some degree uncertain. First, the elegantly segmented compound rays originally referred to *Ptychodus* by Agassiz, and described by me under the species *Saurocephalus thaumas*, appear to be referable to the genus *Portheus*, and to be supports of the caudal fin.*

Secondly, spines composed of unsegmented rays closely united, edge to edge, and arranged like the fulcra at the base of the external rays of the caudal fin of recent fishes; that is, the first very short, those succeeding increasing regularly in length to the last, which forms the apex of the spine. The obliquely truncated extremities of these rods from a continuous sharp edge, which is coated with enamel, and may be straight or interrupted with low knobs. The former kind belongs probably to *Portheus*, and the latter to *Ichthyodectes.* It is nearly related in character to the spines of *Edestus*, the enamel-coated knobs of *Ichthyodectes* rising into veritable teeth in the Carboniferous genus. These spines are unsymmetrical, and belong either to the pectoral or ventral fins. To which they should be referred, it is not now easy to decide. The living allies of the *Saurodontidæ* do not possess ventral spines, nor do they exist in physostomous fishes. In the *Siluroids*, the pectoral fins are supported by strong spines, which remotely resemble the present ones in their compound character.

Thirdly. There are numerous flat, more or less curved, spines or rays of small diameter, compared with the length. One surface is covered with a thin, generally striate-grooved layer of enamel, and one edge is trenchant. One side of this edge is more or less obtusely rugose or thickened. These rays thin out to the extremity, which, in some cases, at least, is not contracted. These rays are composed of appressed halves, are unsymmetrical, with basal hook, and belong, no doubt, to paired fins. If those already described are pectoral, these are ventral, and *vice versa.* A series of them found together had much the form of either of these fins, while their enlarged number would identify them

* See Hayden's Report, *loc. cit.*, p. 423, where this view is held.

with the pectoral. In the rays found together, the first only had a trenchant outer margin, while several had a rabbett along one side of the posterior margin. I have already described such a spine as pertaining to the pectoral fin of *Ichthyodectes prognathus.*

The vertebræ in all the species certainly assignable to this group are, where known, deeply two-grooved on each side, besides the pits for the insertion of neurapophyses and pleurapophyses, except in the cervical region, where the lateral grooves are wanting. There are no diapophyses. The caudal vertebræ are rather numerous, but not so much so as in *Amia*, nor are they so much recurved as in that genus.

Until the structure of the posterior cranial roof and of the scapular arch are fully made out, it is premature to state precisely the affinities of this family. So far as known, they are *Isospondyli*, with some characters of the *Salmonidæ*, and some of other significance. The large foramen behind the prootic bone is more *Clupeoid* in character. The femoral bones are more like those of the *Plectospondyli*, dividing, in a measure, characters of the *Cyprinidæ* with those of the *Mormyridæ*. The vertebræ are *Clupeoid*, while the mode of implantation of teeth is peculiar.

Synopsis of genera.

I. Jaws without foramina on the inner face of the alveolar margin:
  Teeth of unequal lengths in the maxillary and dentary bones .... *Portheus.*
  Teeth of equal lengths, cylindric .... *Ichthyodectes.*
II. A series of foramina on inner side of alveolar wall:
  Teeth with subcylindric crowns .... *Saurodon.*
  Teeth with short compressed crowns .... *Saurocephalus.*

There are some other forms to be referred to this family whose characters are not yet fully determined. Thus, *Hypsodon*, Agass., from the European chalk, is related to the two genera first named above; but as left by its author in the "*Poissons fossiles*," includes apparently two generic forms. The first figured and described has the mandibular teeth of equal length. In the second they are unequal, as in *Portheus*, to which genus this specimen ought, perhaps, to be referred. Both are physostomous fishes, and not related to the *Sphyrænidæ*, where authors have generally placed them. Retaining the name *Hypsodon* for the genus with equal mandibular teeth, its relations to *Ichthyodectes* remain to be determined by further study of the *H. levesiensis*

A species of *Ichthyodectes* from the chalk of Sussex, England, is figured but not described by Dixon in the Geology of Sussex.

A number of forms erroneously referred by Agassiz and Dixon to the genus *Saurocephalus* have been referred by Leidy to a genus he calls *Protosphyræna*,* with two species, *P. ferox* and *P. striata*. The latter much resembles a *Saurocephalus*, having equal teeth, while the former probably includes several species and possibly genera. The teeth first referred to it resemble generically those of *P. striata*, while others resemble those of *Portheus.* An examination of the figures of the mandibles of the last, in Dixon's work, shows that the large and small teeth occupy different areas, separated by grooves, in a manner quite distinct from anything seen in *Portheus;* but should it prove identical, it can scarcely be regarded as typical of *Protosphyræna*, which name, moreover, has never been accompanied by the necessary description.

* Trans. Amer. Philos. Soc., 1856.

Dr. Leidy applied the name of *Xiphactinus* to a genus indicated by a spine in some degrees like those regarded above as pectorals of *Saurodontidæ*. It is quite distinct from those assigned to *Portheus* and *Ichthyodectes*, and may belong to *Saurocephalus*, as already suggested, or to another genus.

PORTHEUS, Cope.

Proc. Amer. Philos. Soc., 1871, p. 173; *loc. cit.*, 1872, February.

Teeth subcylindric, without serrate or cutting edges, occupying the premaxillary, maxillary, and dentary bones. Sizes irregular; the premaxillary, medium maxillary, and anterior dentary teeth much enlarged. No foramina on inner face of jaws. Teeth on the premaxillary reduced in number. Opercular and preopercular bones very thin. Cranial bones not sculptured.

The fishes of this genus were rapacious, and, so far as known, of large size. They constitute the most formidable type of physostomous fishes known. Three species are known to the writer, one from teeth only, from the Miocene of North Carolina, but not certainly known not to be an intrusive Cretaceous fossil, and two from Kansas. The latter are represented by more or less numerous fragments of eleven individuals, three of which possess large portions of the cranium, one almost entirely complete. Two of the remainder embrace jaws, and one, a large part of the vertebral column, with segmented rays. In one, these rays were found with the cutting, compound ray above described, while the simple, flat, pectoral rays occur with several specimens. In none have any traces of symmetrical spinous rays been found, nor strong interneurals capable of supporting such. In none of the more perfect specimens with crania have the segmented rays been found, but the fossil of *P. thaumas*, where they occur, is represented by a vertebral column and its appendages, which do not differ appreciably from those of *P. molossus*.

In the cranium of this genus there is a well-marked supraorbital rim. Each opisthotic forms a prominent angle directed posteriorly on each side of the exoccipital. The parasphenoid is a stout and narrow bone, deeply emarginate behind for the passage of the muscular canal. It has a transverse expansion in front of the base of the proötic, which rests on a backward continuation of the same. This expansion is pierced behind by two round foramina. The shaft is abruptly contracted in front of the expansion and is trigonal in section. The prefrontal extends downward and forward and carries inferior and anterior articular faces, the latter vertically transverse. The postero-inferior portion of the ethmoid bears on its posterior extremity a concave articular face, which opposes that of the prefrontal. The floor of the brain-case in front is supported by a vertical style, which is bifurcate above and rests on the parasphenoid.

Of the teeth in general, it may be added that their pulp cavity is rather large at the base but rapidly diminishes in the crown. The mode of succession is by direct displacement from below. The young crown rose into the pulp cavity and destroyed the vitality of the crown while the root was absorbed. Numerous empty alveoli are to be found in all the jaws of this genus, in which examination will often detect the apex of the crown of the young tooth.

The vertebræ in this genus are rather short, but not so much so as in sharks. In *P. thaumas* nearly eighty dorsals and caudals were preserved; those without lateral grooves or cervicals (the name not appropriate)

are not numerous. There are, perhaps, not more than four vertebræ supporting the caudal fin; though this is difficult to determine, owing to the concealment of the terminal centra by bases of radii. There are seven hæmapophyses in the support, all flat except the first, which is like those anterior to it. The second is articulated freely to its centrum, and is wider than the others. Its condyle is characteristic, being double, and with a foramen between it and the produced extremity of the posterior margin of the bone. It is slightly separated distally from the third, but the remainder are in close contact. The radii of the superior lobe of the caudal fin extend at least as far down as near the end of the third hæmal spine from below. The structure of these parts in the *P. molossus* are as in the *P. thaumus*, so far as preserved.

As some of the spines are not referable to their precise species in this genus, they may be described here. A large compound spine, found in the blue limestone shale in Fossil Spring Cañon, is composed at the base of about twenty-six narrow, double rods. A few appear between the others beyond the base, making thirty-one altogether. They are very oblique to the general base, but curve so as to become nearly straight, and enlarge distally. They terminate in a thickened portion, which bears an acute edge, which truncates them obliquely. This portion is enameled; the edge is slightly convex at the base, and slightly concave at a point probably beyond the middle.

Measurements.

	Meters.
Length of fragment, (12 inches)	.30
Width at base	.12
Thickness at base	.012
Thickness at broken end an inch from edge	.007

This is a formidable weapon, and could be readily used to split wood in its fossilized condition.

The third species of spine is represented in most of the species, but one series of rays with spine may not be referable to any of them. The latter is flat and curved, the convex edge trenchant beyond the middle. The posterior edge is obtuse but narrow, and exhibits a slight groove on one side medially; proximally there is a shallow rabbett, whose floor is transversely rugose. Several layers of the tissue of the spine beyond the basal portion are delicately, longitudinally striate. The distal half is broken away. Length of fragment, 1 foot; width, 1.5 inches; thickness at middle, 5 lines.

The species of this genus may be distinguished as follows:

a. Teeth without acute edges:
- Larger maxillaries, 5; second premaxillary larger than first; third mandibular large, behind a cross-groove; last large mandibular followed by 16—8 small teeth .... *P. molossus.*
- Larger maxillaries, 3; first premaxillary larger than second; third mandibular small, no cross-groove in front of it; 20 small teeth behind last large mandibular .... *P. thaumas.*

aa. Large teeth with cutting angle in front:
- Teeth large, not compressed .... *P. angulatus.*

ICHTHYODECTES, Cope.

Proc. Amer. Philos. Soc., 1870, Nov.; Hayden's Geol. Survey, Wyoming, &c., 1871, p. 421.

Teeth equal, subcylindric, in a single row, sunk in deep alveoli. Premaxillaries short. No foramina at the bases of the teeth on the inner alveolar walls. Vertebræ deeply grooved laterally.

The species of this genus are, so far as known, smaller than those of the last, and, as their remains are more perishable than those, form a less striking object among the fossils of Kansas. They are, nevertheless, very abundant, especially in species, five of which are now described. In originally describing this genus the vertebræ were regarded as not grooved, in consequence of such vertebræ having been discovered along with the bones and teeth of *I. ctenodon.* Further examination has satisfied me that this union is erroneous, and that the bones, if found together, were accidentally so.

Spines similar to those of the *Porthei*, but presenting certain differences, may be ascribed to this genus. The compound segmented spines cannot be ascribed to it, but the compound fulcrum-like spines are similar, though composed of fewer and stouter rods. Each of these, as it terminates at the cutting edge, gives rise to a projection, giving it an obtusely and remotely serrate character. It is rugose with enamel deposit, and constitutes as effective a weapon of defense as that of *Portheus.* One which is nearly perfect contains fifteen pairs of rods, which expand at the base as do the rays of a pectoral fin. Total length, .235 meter; width at base, .04 meter; thickness beyond base, .006 meter.

The femoral bones have already been described. The maxillary is not contracted at the end for a supernumerary bone, as in *Portheus.*

The form of the inferior quadrate is like that of *Portheus.* In *I. anaides* the groove for the preoperculum extends low down, and the symplectic has a wider exposure on the outer face than in *Portheus.*

In a series of vertebræ similar to those of this genus, those included in the basis of the caudal fin are not more than three in number.

The species are distinguished as follows:

Premaxillary teeth, 5, second most prominent; maxillary not concave; dentary with 30 teeth and biconvex, alveolar border, with obtuse extremity.... *I. anaides.*
Premaxillaries; maxillary straight, large, with 40 teeth; dentary straight, not produced at end; teeth, 26.................................... *I. ctenodon.*
Premaxillaries, 5, first most prominent; maxillary concave, narrow; teeth small; dentary with a hook at apex; teeth, 25.............................. *I. hamatus.*
Premaxillaries, 7, first most prominent, compressed, smaller .... *I. prognathus.*
Premaxillaries, 12, second most prominent; the bone much narrowed above, smaller...................... *I. multidentatus.*

The English species of this genus is figured by Dixon in the Geology of Sussex, Pl. xxxii, Figs. 9 and 9*. I can find no letter-press nor name relating to it, and cannot determine its specific characters from the fragmentary character of the piece of mandible figured.

SAUROCEPHALUS, Harlan.

Leidy has pointed out the mode of implantation of the teeth in the typical species of this genus. The mode of succession of the teeth has

not yet been indicated, but is well displayed in a specimen of the jaw of *S. arapahovius*, Cope. It is known from Harlan's description that a large foramen issues on the inner wall of the jaw, opposite each root. The fractured ends of the specimen exhibit the course of the canal which issues at this foramen. It turns abruptly downward between the inner wall of the jaw and the fang of the functional tooth, and not far from the foramen, its course is interrupted by the crown of the successional tooth. This is situated obliquely as regards the long axis of the jaw.

It is thus plain that the successional appearance of teeth is different in this genus from what I have described in the two genera preceding. In them the foramen is wanting, and the young crown rises within the pulp cavity of the functional teeth, as in the *Crocodilia*. In this genus, on the other hand, it is developed outside of the pulp cavity and fang of the old tooth, and takes its place, as in many *Lacertilia* and in the *Pythonomorpha*, by exciting the absorption of the latter. The conic form of these fangs in *Saurocephalus* is appropriate to such a succession, and their great length seems to preclude the nutrition of the young tooth from their bases. The use of the foramina on the inner face of the jaw is thus made apparent, viz: The nutrition of the successional teeth from without. I cannot trace the canal below the crown of the young tooth to the base of the pulp cavity of the old tooth, and there are canals in the jaw below the latter, one of which probably carried the dental artery.

Species of this genus are less abundant in the part of Kansas examined by me than those of the preceding genera. Two only have been observed up to the present time, *S. arapahovius* and *S. phlebotomus*, Cope.

PACHYRHIZODONTIDÆ.

This family of physostomous fishes differs from the last in the nature of its dentition. Instead of elongate, conic fangs sunk in deep alveoli, it has shorter and stout fangs occupying alveoli of which the inner side and part of the anterior and posterior walls are incomplete. The teeth are, in fact, more or less pleurodont, but the extremity of the root is received into the conic fundus of the alveolus.

The premaxillary bones are well developed, but the maxillaries are more so, and enter largely into the composition of the border of the mouth. There is a well-developed angle of the mandible, but no coronoid bone is preserved in the specimens. The coronoid region is, however, broken in all of our specimens. The other characters of the family are not determinable from our imperfect materials.

PACHYRHIZODUS, Agassiz.

Dixon's Geology of Sussex, 1850, p. 374.

This genus was established by Professor Agassiz on a jaw-fragment from Sussex, England, with a brief description. The Kansas remains resemble this fragment in their corresponding parts, and I refer them to the same genus for the present.

The genus as seen in our fossils is defined as follows: Muzzle flat; premaxillary bones rather long, with two larger teeth together near the anterior end behind the usual external series; maxillary and mandibles with a single series of simply cylindric, curved teeth; mandibular rami closely articulated by a ligament.

The teeth in this genus bear a superficial resemblance to those of a mosasauroid genus. Their mode of succession appears to be as follows: The crown of the young tooth was developed in a capsule at the base of

the crown, or on the inner side of the apex of the thick root. The absorption which followed excavated both the former and the latter, but the crown was evidently first shed. Then the old root disappeared, and the new one occupied the alveolus, leaving a free separation all round. Finally, on the accomplishment of the full growth of the root, it became anchylosed to the alveolus all round. The pleurodont position of the tooth facilitated the shedding of the root very materially.

The genus *Conosaurus*, Gibbes, from South Carolina, is perhaps allied to this one. Its dentition is fully described by Leidy, who changes the name to *Conosaurops*, mainly on account of the inappropriateness of the Greek *Σαυρος* to a fish. This word was, however, employed by the ancients to designate a fish, and the only use made of the word, out of composition by modern zoologists, is for species of that class, so that it does not seem improper to use it here.

Three, perhaps four species, left their remains in the strata examined by the expedition.

EMPO, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 347.

This genus differs from the last in possessing large canine teeth in the front of the maxillary bone, posterior to which are two series of usual size. The inner or superior of these takes its rise from the canines and has no great extent, while the outer is marginal. Teeth cylindric-conic, and in the type species somewhat incurved. But one species was found, the *E. nepaholica*, Cope, a fish as large as a pike of forty pounds.

STRATODONTIDÆ.

In this group I have arranged several genera, which resemble *Enchodus*, the largest known of its forms. They are physostomous fishes, as indicated by the relations of bones of the superior arch of the mouth, the absence of spinous dorsal radii, the cycloid scales, and the general relationship to *Esox*. Agassiz and others have regarded some of them as allied to *Sphyræna;* this opinion was probably derived from a consideration of the forms of the teeth, which, to some degree, resemble those of *Sphyrænidæ* and *Trichiuridæ*. This is, however, like many other minor characters, one of those which appear in both of the great groups of osseous fishes.

The premaxillary is small, and supports a large tooth in *Enchodus;* in *Stratodus* it is also short and supports numerous teeth. In *Stratodus* the maxillary supports a few teeth; in *Cimolichthys* a larger number. Relationship to *Esox* is displayed by *Stratodus*, which has broad, flat palatine bones, closely studded with teeth in a brush, and where the maxillary teeth are reduced in size and number. The teeth are attached by the anchylosis of the base to the alveolar face of the jaw, resembling thus existing fishes, and differing materially from the families of *Pachyrhizodontidæ* and *Saurodontidæ*, already considered.

The genera known to me are the following:

Premaxillary with numerous small teeth; maxillary with a few of the same; palatines covered with brushes of similar teeth, all with pulp cavity.................. *Stratodus.*

Premaxillary ?; maxillary with a single series of large teeth, which have one cutting edge at base and two at apex; dentary with inner series of large teeth, which do not enlarge distally, and some series of exterior smaller teeth.................................. *Cimolichthys.*

Premaxillary with a single large tooth; dentary with an outer row of small and an inner row of large teeth, which are much larger at the distal end.............. *Enchodus.*

STRATODUS, Cope.

This genus is well characterized by its dentition, which is remarkable for the small size and large number of the teeth, and their peculiar form. I possess one premaxillary, a considerable part of the maxillary, and nearly the whole of both palatines, besides other bones, of one species. These were found not very far from the remains of the *Cimolichthys semianceps*, M., and it required some investigation to determine the relationship between them. I have, however, portions of the maxillary and premaxillary of *Cimolichthys*, and both of these elements are so very unlike those in *Stratodus* that there can be no doubt of its independence. I have unfortunately no dentary bone of *Stratodus*, and the outer row of palatines resembles, in some measure, those figured in *Cimolichthys levesiensis*, Leidy, by Agassiz.

The premaxillary teeth are in two series. They are stout at the base and oval in section, and are contracted and flattened rapidly upward. On this basis is set an oval, sharp-edged, flat or spade-shaped crown, the long axis of compression being placed at right angles to that of the compression of the apex of the base. This gives a barbed appearance. The *maxillary* teeth are similar in form, but are in but few rows. The *palatine* teeth are constructed on the same plan, but they are longer, and the bases are subcylindric and slightly curved. All the teeth possess a large pulp cavity.

The *premaxillary* bone displays some of the density of composition seen in *Enchodus*. Its upper anterior surface meets the inferior at an acute angle. It is a broad oval, and is slightly concave. The inner face forms a truncate rim round the bases of the inner teeth, and terminates in a vertical crest of dense bone. The external face is, on the other hand, perpendicular, and extends obliquely upward and backward. An acute anterior angle of the *maxillary* underruns it below, so far as to exclude all but one or two of the premaxillary teeth from the outer row. The external lamina of the premaxillary forms an extensive squamosal suture with this part of the maxillary by overlapping it from above. This arrangement shows a certain similarity to *Esox*, especially in the large number of palatine and small number of maxillary teeth. It differs materially in the lack of articular surfaces between the maxillary, palatine, &c., in the upward prolongation of the premaxillary, and the peculiar forms of the teeth.

CIMOLICHTHYS, Leidy.

Proc. Acad. Nat. Sci., Phila., 1856, 302; Trans. Amer. Philos. Soc., 1856, p. 95; *Saurodon*, Agassiz, pt. Poiss. Foss.

In this genus the principal teeth are stout, and have a compressed apex, with a prominent anterior cutting edge, and a less extended posterior one. There are several series of smaller teeth, external to the large ones in the lower jaw, while in a portion of an upper jaw of one of the species these are wanting. Where present, they are more acute than the larger ones. The large teeth diminish gradually in length to the symphysis, a circumstance which separates these fishes from *Enchodus*, where one or more of the anterior teeth are elongate. In

the species here described, the bases of the teeth are enlarged and deprived of cementum coat, but there are no true roots.

The maxillary bone terminates in a narrowed extremity, with obtuse termination, as in *Stratodus*. The vomer in one of the species is acuminate at one end, and supports a short series of teeth; the middle portion in a double row. All the teeth are without pulp cavity.

The only indication of the mode of succession of the teeth is furnished by the specimen of *C. anceps*. Here a small excavation appears on the inner side of the basis of the tooth. The absorption, commencing at this point, no doubt removes the basis so that the crown falls away.

The name used was applied by Dr. Leidy to a fish erroneously referred by Agassiz and Dixon to *Saurodon*, Hays. He did not characterize it; and until the barbed palatine teeth, characteristic of it, are discovered in our species, their reference to it will not be fully established. In the parts preserved they appear to be identical. The general affinities of the genus will receive new light from materials now in my possession and not yet developed.

The *Sphyræna carinata*, Cope, (Hayden's Report, Wyoming, &c., p. 424,) probably belongs to *Cimolichthys*.

ENCHODUS, Cuvier.

Remains of species of this genus occur in the Cretaceous strata of Kansas. I discovered a tooth belonging to one of them in the matrix beneath the vertebræ of *Elasmosaurus platyurus*. Dr. Leidy described a species from the Cretaceous formations of the Upper Missouri region, which he called *E. shumardii*. The premaxillary of a rather large species was obtained by my expedition; but the species is not determinable. The diameter of the basis of the tooth is .012 meter. The long tooth of a species of medium size was detected, the *Enchodus calliodon*, Cope. (Spec. nov. *Enchodus* sp., Cope, Hayden's Surv. Wyoming, &c., p. 424.)

SELACHII.

Remains of sharks and rays are far less abundant in the Cretaceous of Western Kansas than in New Jersey, and are much exceeded in abundance by the physostomous *Actinopteri*, as the present account indicates. In the region near Fort Hays and Salina, sharks' teeth are more frequently found. Those from near Fort Wallace belong to but two species of the genus. *Galeocerdo Müll. Henl.*

GENERAL OBSERVATIONS.

The following species have been described from the Cretaceous formation of Kansas:*

SAURODONTIDÆ.

Portheus molossus, Cope.
thaumas, Cope.
Ichthyodectes anaides, Cope.
ctenodon, Cope.
hamatus, Cope.
prognathus, Cope.
multidentatus, Cope.

* The species here enumerated are all described in the Proceedings of the American Philosophical Society for February, 1872.

? *Xiphactinus audax*, Leidy.
Saurocephalus phlebotomus, Cope.
arapahovius, Cope.

PACHYRHIZODONTIDÆ.

Pachyrhizodus caninus, Cope.
kingii, Cope.
latimentum, Cope.
sheareri, Cope.
Empo nepaholica, Cope.

STRATODONTIDÆ.

Stratodus apicalis, Cope.
Cimolichthys sulcatus, Cope.
semianceps, Cope.
anceps, Cope.
gladiolus, Cope.
? *carinatus*, Cope.
Enchodus calliodon, Cope.

FAM. ?

Apsopelix sauriformis, Cope, Hayden's Report Wyoming, 1871, p. 423.

SELACHII.

Galeocerdo crassidens, Cope.
Hartvellii, Cope.

Of the preceding twenty-four species the greater part are physostomous *Actinopteri;* and there is no species of a physoclystous family in the list. No trace of spines or scales of fishes of the latter character have been yet discovered in strata of this period in the West, though one (*Beryx insculptus*, Cope) has been discovered by Dr. Lockwood in the green-sand marl of New Jersey.

In the second place, it is of importance to observe that the genera have nearly all been obtained from the chalk of Europe. *Portheus* is represented, perhaps, by some specimens referred to *Hypsodon;* one species of *Ichthyodectes* is figured by Dixon, from Sussex; and one of *Cimolichthys*, and *Pachyrhizodus*, each. *Enchodus* has long been known from Holland, etc.; *Empo Apsopelix* and *Stratodus* being so far the only ones not found in Europe. This is of much interest in every aspect, and points to a synchronism, as generally understood, between the chalk formations of Kansas and of England.

MOLLUSCA.

Species of this division of animals are not numerous in the beds of the Niobrara epoch. They consist chiefly of *Inocerami* of two or more species. Through the kind assistance of my friends, N. Daniels, of Hays, and Dr. J. H. Janeway, post-surgeon at Fort Hays, I was enabled to procure a number of very complete specimens of some remarkable shells from the yellow chalk. They were found on a denuded tract of the yellow chalk, near the Saline River, and were quite exposed. They resemble generally large oysters, some of them measuring as much as twenty-seven inches in diameter. I submitted the specimens to my colleague,

T. A. Conrad, and add herewith his account of them. He thinks they possess some resemblance to the *Rudistes*; but whether truly related to or belonging to that division, he is at present in doubt.

Fragments of these *Haploscaphæ* are common in the formation, and have been described by authors as portions of huge *Inocerami.*

HAPLOSCAPHA, Conrad.

Shell subovate or subtriangular; hinge long and straight, edentulous, oblique; curved, prominent ridges occupy the upper portion of the interior, the ridges beginning and ending at a distance from the margins of the shell; a singular twisted callus composes the hinge, the back of which is transversely ribbed.

H. GRANDIS.—Length greater than height, hinge-line very long, ridges concentric, about twelve in number, extending into the cavity under the hinge.

This shell, Professor Cope informs me, has been found 27 inches in diameter. The posterior side of the right valve is elongated and dilated, and the form of the shell is not unlike that of *Meleagrina.* The substance is fibrous or rather columnar, and much resembles that of *Caprinella* as figured by d'Orbigny, except that the fibres are transverse. The exterior is always concealed by a coating of rock and a crowded mass of *Ostrea congesta*, and in some specimens they line the cavity of the shell; the submargin is thick. No muscular impression can be traced unless the ridged part indicates its station.

Subgenus CUCULLIFERA.

Shell with an upright, hood-shaped process on the posterior end of the hinge.

H. EXCENTRICA.—Ovato-triangular; hinge-line short, very thick; concentric ridges profound, six in number; hood strongly and irregularly plicated; cavity profound.

This shell, with the same structure of substance as the preceding, is very unlike it in form, and is represented by one valve only, while a number of the preceding species were found. In all specimens of the two forms the right valve only was obtained.

Whether it is allied to the family *Rudistes* of Lamarck is a question I leave for others to decide. On the margin of one of the valves are attached some small shells resembling *Hippurites*, and the fibres of which the shell is composed lie in broken masses on some valves and even scattered like piles of pins.

The hood of *H. excentrica* is 2½ inches in height, and the height of the valve 10 inches; length, 9 inches.

Accompanying these fossils were many specimens of *Inoceramus problematicus*, and a fragment of an undetermined species of the same genus.

ON THE VERTEBRATE FOSSILS OF THE WAHSATCH STRATA.

By Edward D. Cope, A. M.

Dr. Hayden's researches in Utah and Wyoming have demonstrated the existence of an extensive series of fresh-water deposits, containing numerous remains of animals and plants. Those of Western Wyoming, or the Bridger series, are regarded as Upper Eocene or Lower Miocene. They thin out to the westward, and a new series of strata takes their place, dipping to the eastward. The Bridger beds are not strictly conformable to them, while they rest uncomformably on a bottom-rock of Cretaceous age. These are the Wahsatch beds of Hayden. He informs us that they consist largely of variegated ferruginous rocks, very deficient in fossils. During his recent exploration, however, he procured a number of bones of mammalia from Utah, and placed them in my hands for determination. The following description expresses their characters, from which it is obvious that the forms they represent were of much interest in a systematic point of view.

Order *Perissodactyla.*

BATHMODON, Cope.

Proc. Amer. Philos. Soc., 1872, February 16.

The present form embraces some of the largest *Perissodactyles*, or odd-toed *Ungulata*, of our Tertiary strata. It is represented by remains of two species, which include portions of the cranium, with teeth and fragments of jaws, vertebræ, fragments of scapular and pelvic arches, and bones of the limbs. The distal end of the tibia is wanting, but that of the fibula indicates an odd-toed animal, and the third trochanter on the exterior ridge of the femur confirms the reference.

There are probably four superior molars, though three only are preserved. Two premolars only remain of the superior series, but the fragment of *ramus mandibuli* referred to the same species exhibits four premolars; from a consideration of the sizes of the superior premolars it is probable that there were four of these also. There are three strong incisors in each premaxillary. No canine tooth is preserved, but the posterior suture of the premaxillary bone is so wide as to point to an equally stout anterior part of the maxillary fitted to support such a tooth. The dental series increases regularly in size, from before backward, the last being a little larger than the penultimate. The crowns of the molars exhibit on the outer margin a single acutely angled crescent directed inward, with a conic lobe alongside of and anterior to its base, representing a second external crescent. The crescent lobe proper is large and very obliquely directed, so that its external face is almost horizontal. The apex of its companion cone is continuous with its posterior margin, so as to be undistinguishable from it in some cases. The inner crescents are represented by a wide angular ridge, which is at a lower level than the exterior, and is little or not developed on the posterior side of the crown. Its inner plane face is horizontal, or even ascending in one species. In the premolar teeth of *B. radians* the external crescent lobe is single and symmetrical. As the crown contracts inwardly a second inner crescent lobe has a trihedral form, while in one more anterior the inner is much reduced. The inferior premolars are

all two-rooted, and form an uninterrupted series. The basis of the malar part of the zygomatic arch originates opposite the adjacent parts of the penultimate and last molars. The premaxillary bone is massive, and with but little area for attachment with its fellow in front. The incisor teeth are large, with subcylindric roots, and their alveoli are well separated. In one, perhaps superior, the crown is expanded transversely, with convex cutting edge.

In the humerus the deltoid hook is developed, but is not much elevated above the plane of the head. It originates from an external expansion of the head, which bears a shallow cotylus separated from the head by a low, curved, subtransverse ridge. The condyles of the humerus do not support any trochlear ridges. An almost perfect femur of *B. radians* is preserved. The third trochanter is not very prominent. The little trochanter is little developed. The great trochanter is large but does not equal the head. The latter is subglobular, and the ligamentous fossa extends to its rim. The distal trochlear surface is prominent, the inner edge more so than the outer. Its articular surface is broadly continuous with those of the condyles; a slight emargination of the outlines only marking the usual constriction on each side. In this it resembles *Cervidæ* and some *Antilopidæ*. The inner condyloid surface is cut off by the emargination in *Toxodon* and *Bos bubalus*; the emarginations are deep, but do not cut off either in *Equus*, *Camelopardalis*, and three species of *Bos;* while they are so deep as to cut off both in *Rhinoceros*, 5 species—*Hippopotamus*, *Bos brachycerus*, *B. sondaicus*, and in *Catoblepas*.

A portion of the co-ossified parietals shows that the superior borders of the temporal fossæ were separated by a flat plane, as in the hog and other ungulates.

BATHMODON RADIANS, Cope.

Proc. Amer. Philos. Soc., *loc. cit.*

Represented by portions of several individuals, which indicate an animal varying from the size of the ox to that of the Javan rhinoceros.

The transverse diameter of all the molars exceeds their longitudinal. In the penultimate, which may serve as a type, the superior or outer plane of the inner crescent ridge extends along about .66 of the posterior of the outer crescent. In the last molar this surface is very wide on the posterior and inner side of the external crescent; it then contracts and expands again on the posterior side, its outer bounding crest reaching to the external margin of the crown.

Besides these points, the molars possess a strong cingulum along the anterior base of the crown, which unites with the surface near the inner protuberance of the latter in the penultimate; in the last molar it reappears, forming a short lobe on the posterior face. The enamel where not worn is slightly rugose.

A posterior premolar has a cingulum on the inner obtuse apex. The crest of the inner crescent, descending on each side of the apex of the outer, forms a cingulum-like ledge at its base as far as the angle formed by the descent of the apex of the outer crescent. The outline of the corner of this tooth, viewed from above, is narrow cordate, with obtuse apex. The convexity of the outer crescent inward is very strong, and the base of the crown is externally two-lobed. Enamel striate rugose. In a more anterior premolar (with three roots) there is no internal cingulum, and the crest of the inner crescent is not carried to the external basis of the tooth, and is entirely wanting on the posterior face of the

tooth. The external crescent is more vertical and less concave. Outline of crown subtriangular.

The premaxillary bone is elongate, flat, and with a sloping superior face, which rises gently inward. The bases of the incisors stand obliquely outward. The inferior surface is flat, and the basis of the broken palatal spine is rather small. An incisor tooth has a transversely diamond-shaped crown, slightly twice concave on the inner faces, strongly convex on the outer, with a faint external cingulum near the external angles. Enamel obsoletely striate.

Measurements.

No. 1.

	Meters.
Longitudinal diameter last superior molar	.035
Transverse diameter last superior molar	.0455
Longitudinal diameter penultimate molar	.032
Transverse diameter penultimate molar	.039
Longitudinal diameter posterior premolar	.024
Transverse diameter posterior premolar	.034
Longitudinal diameter anterior premolar	.0215
Transverse diameter anterior premolar	.0265
Length premaxillary bone	.082
Transverse width posterior suture	.028
Width premaxillary at middle suture	.043
Length basis last two inferior premolars	.057
Transverse diameter edge of mandible at first premolar	.017
Diameter condyles of femur	.104
Diameter heads great trochanter	.130
Diameter head alone	.062
Diameter shaft with third trochanter	.076
Supposed length femur (16.75 inches)	.415
Transverse diameter head of tibia	.092
Antero-posterior diameter head of tibia, internal	.061
Antero-posterior diameter head of tibia, external	.045
Transverse width between temporal fossæ	.066

(?) No. 2.

Longitudinal diameter head of humerus	.138
Longitudinal diameter of outer cotylus and tuberosity	.055

The other remains of this animal will be more fully described and the whole figured in the final report. They were discovered by Dr. F. V. Hayden in Tertiary beds of the Wahsatch group near Evanston, Utah.

BATHMODON SEMICINCTUS, Cope.

Loc. cit.

This species differs from the last in several particulars of dentition. The interior ridge (homologous with the inner crescentic) bounding the middle plane of the superior molars, is not continued on the posterior face of the tooth, but curving inward joins the outer crest at its apex. The outer crest terminates in a conic tubercle anteriorly on the external face; the rudiment of the anterior crescentic ridge appearing as a low ridge from the side of the posterior one, and rising to a point on the an-

terior margin of the crown. There is no cingulum round the anterior base of the crown. The latter is as long as wide. The inner crest is reduced to a mere angle, and its posterior face is not basin-shaped, but rises to the crest of the inner crescent. The outer face of the latter is sub-horizontal with rising apex, and is concave transversely. Its anterior outer base is narrowed, but is less elevated than the posterior.

Measurements.

	Meters.
Length basis crown	.0225
Width basis crown	.022
Width exterior crescent	.012
Depth exterior crescent	.02

This animal was not more than half the bulk of the last; its size was about that of the *Tapirus terrestris*. The differences in dentition, which it presents in the possession of a rudimental, anterior external crescent lobe, are so marked, as compared with the last species, as to induce me to believe that it will be found on fuller acquaintance to belong to another genus. This may be called *Loxolophodon*. Other remains belonging to this species, or relating to it in size, are contained in Dr. Hayden's collection, but cannot now be referred to it with certainty.

From the Wahsatch beds near Evanston, Utah.

Especial interest attaches to these fossils from the fact that they belong to the oldest of the Tertiary periods of North America. Their affinities can only be explained in a general way. They represent a family distinguished from the type of *Titanotherium* and *Palæosyops*, Leidy, in the presence of only one external crescent lobe of the molars, the place of the other being taken by a tubercle or ridge. The general characters are partly perissodactyl and partly ruminant, and not in any great degree suilline.

ON THE FOSSIL VERTEBRATES OF THE EARLY TERTIARY FORMATION OF WYOMING.

BY PROF. JOSEPH LEIDY.

The Tertiary formation of the Green River Basin of Wyoming equals, if it does not exceed, in interest that of the *Mauvaises terres* of White River, Dakota, and that of the Niobrara River, Nebraska. It is evdently older than these, and indeed belongs to another age in succession with them. The Green River Tertiary is probably the equivalent of the Eocene Tertiary; that of White River, of the Miocene; and that of the Niobrara, of the Pliocene.

The first fossil obtained from the Wyoming Tertiary formation was a small herring, from the Green River shales, described in 1856 by the writer, under the name of *Clupea humilis*. The first crocodile from the vicinity of Fort Bridger was brought to the notice of the writer in 1868. The ifirst turtle, discovered by Prof. Hayden in the same locality, and the first mammal, discovered by Dr. J. Van A. Carter, the same year, were also described by the writer. Since that time to the present, no less than seventy-one vertebrated animals have been indicated, mainly from collections made during the explorations of Prof. Hayden in

1869 and 1870; from by Dr. collections made Carter from 1868 to 1871; and from collections made by Dr. Joseph K. Corson, U. S. A., in 1871; and Prof. O. C. Marsh, during the preceding year.

Of the seventy-one vertebrated animals, for the most part clearly characterized, thirty-four are mammals; one, a bird; twenty-five, reptiles; and eleven, fishes. This assemblage of vertebrates presents no giants; but, on the contrary, they are nearly all comparatively small forms. Among the mammals, the order of pachyderms presents species smaller than any now in existence, and as small as any that have been found in other formations elsewhere.

The thirty-four mammals belong to twenty-two genera, all of which are extinct except one, the genus *Canis*. The imperfect remains referred to this may, on the discovery of more complete material, be found to belong to another and perhaps an extinct genus. Sixteen of the twenty-two genera are peculiar to the Wyoming Tertiary, or have not elsewhere been discovered in other formations. Of the five previously known genera, *Lophiodon* and *Lophiotherium* belong to the early Tertiary formation of Europe; *Elotherium* belongs to the middle Tertiary formation of Dakota and of Europe; *Titanotherium* belongs equally to the lowest stratum of the Miocene Tertiary of the *Mauvaises terres* of Dakota; and *Platygonus* belongs to the Post-Pliocene formation of the United States.

Of the genera of mammals, four belong to the carnivora, three to the insectivora, three to the rodents, ten to the odd-toed pachyderms, and two to the even-toed pachyderms. Primates, bats, solidungulates, proboscidians, ruminants, marsupials, and edentates are not represented. Seals, zeuglodonts, and cetaceans we do not look for in fresh-water deposits.

More than half the species of mammals—nineteen—appear to be perissodactyles or odd-toed pachyderms, animals whose nearest living relatives are the Tapir, the Hyrax, and the Rhinoceros.

Strange is it that there is not a single ruminant among all the mammals. These animals appear not to have formed members of the ancient Tertiary fauna of Wyoming. Tapir-like pachyderms, small Hyrax-like animals, rodents, insectivores, and carnivores appear to have constituted the chief mammalian life. Ruminants, solipeds, and proboscidians appear to have come at a later period into existence, as indicated by the Tertiary deposits of White River, Dakota, and the Niobrara River, Nebraska.

A single owl and a stray feather tell us that ancient Wyoming had its birds, but the paucity of material gives hardly a glimpse of the character of the class.

Crocodiles were numerous in the early Tertiary period of Wyoming, as indicated by their many remains. Six species have been named. No traces of these animals have been discovered in the middle and later Tertiary formations of White River, Dakota, and Niobrara River, Nebraska.

The land and waters of ancient Wyoming swarmed with turtles. The Tertiary deposits of Dakota and Nebraska have yielded each but a single species. The Tertiary deposits of Wyoming present us with abundant evidences of the former existence of nine species. Of these one was a *Testudo* or Land-Tortoise, as big as its modern representative of the Gallipagos Islands. Two others belonged to the same genus, which includes many of our living terrapenes, and one was a soft-shelled turtle of the still-existing genus *Trionyx*. The other five turtles belong to four peculiar genera, not noticed in other formations and times. Several of them are related to our snappers, others to the terrapenes.

Lizards, also, like the iguanas and monitors, existed in the old Wyoming fauna. Five species of two peculiar genera have been indicated. Most of them were inclosed in a bony armor of beautifully ornamented scales, reminding one of those of the Armadillo.

Serpents, too, appear to have been abundant, most of them of the constricting kind, like the South American boas of to-day, but comparatively like most of the other animals of the old Wyoming fauna, of small size. Prof. Marsh has collected remains of snakes, which he refers to no less than five species of three previously undescribed genera.

Some of the shales of Green River teem with well-preserved fishes, sometimes appearing as if whole shoals had been suddenly enshrined for the contemplation of future ages. Seven species have been indicated, of which two belong to the same genus as our Herring. Another species belongs to a genus now existing in South America and Borneo. The others belong to two peculiar genera, described by Prof. Cope. Remains of ganoid fishes are likewise abundant in the Green River Tertiary basin. Some of these Prof. Marsh has referred to four species of the same genera as our Bony Gar and southern Mud-fish.

MAMMALS.

CARNIVORA.

Of carnivorous mammals, a number of remains have been obtained from the Tertiary formation of Wyoming, but generally in so imperfect a condition that their exact relationship has not been ascertained.

PATRIOFELIS.

Patriofelis ulta.

An animal to which this name has been assigned was inferred from portions of a lower jaw, obtained by Prof. Hayden in the vicinity of Fort Bridger in 1869. It was larger than our living Panther, and was apparently related with this and the canine family. The lower jaw contains five molar teeth, immediately succeeding the large canine without a conspicuous interval, as in some of the weasels and civets. A large premolar tooth, probably of the same animal, was obtained near the same locality as the former specimens.

SINOPA.

Sinopa rapax. n. S.

This name has been given to a smaller carnivorous animal, indicated by a lower jaw fragment with two teeth, discovered in the vicinity of Fort Bridger by Dr. J. Van A. Carter, and obligingly sent to the writer the last spring. The animal was about the size of the Gray Fox, and appears to have been intermediate in its position to the weasels and the canine family.

The teeth in the specimen appear to be the last premolar and the succeeding sectorial molar. The former is larger than the latter and exceeds that of the Gray Fox. The principle cusp exhibits a denticle on its back border, but feebly developed in comparison with that in a similar position in the animal just named. The heel of the crown has an acute edge, from which it slopes to the basal ridge.

The crown of the sectorial tooth has the same general form as in the corresponding tooth of the Fox and Weasel. The fore part is proportionately less well developed than in the former; and the inner cusp is

half as large as the outer one. The notch of the sectorial border is directed more forward than in the Fox, and does not terminate in a cleft. The heel or back portion of the crown occupies nearly half its breadth and incloses a cup-like concavity as in the Weasel. The breadth of the crown of the two teeth is nearly the same, being 4 lines; the height of that of the premolar is $3\frac{1}{2}$ lines; of that of the sectorial molar, $2\frac{3}{4}$ lines.

CANIS.

Canis montanus.

Some remains from Grizzly Buttes, Wyoming, are described by Prof. Marsh, and referred by him to a species of wolf under the above name. It was larger than the existing Gray Wolf.

VULPAVUS, *Marsh.*

Vulpavus palustris.

An extinct carnivore, described by Prof. Marsh, from remains found by Dr. Carter near Fort Bridger, Wyoming. The animal was smaller than the Fox.

INSECTIVORA.

It was through Dr. J. Van A. Carter's discovery of the remains of a small insectivorous animal, in association with an abundance of fragments of turtle-shells, in 1868, that our attention was first especially directed to the Tertiary formation of Wyoming, which has since yielded such an abundance of evidences of early mammalian life.

OMOMYS.

Omomys Carteri.

The remains, consisting of one side of the lower jaw and portions of the cranium, were found by Dr. Carter, imbedded in a stratum of green, friable sandstone, in the vicinity of Fort Bridger. The jaw and its contained teeth indicate an animal apparently nearly related, if not actually belonging, to the family of the Hedge-Hog. The specimen is fully described and figured in "The Extinct Mammalian Fauna of Dakota and Nebraska," &c., p. 408, Pl. xxix, Figs. 13 and 14.

PALÆACODON.

Palæacodon verus.

Another insectivorous mammal, though probably a marsupial, like the Opossum, is indicated by several specimens discovered the last summer by Dr. Carter, at Lodge-Pole Trail, Wyoming. One of the specimens, a fragment of an upper jaw, contains a back-molar tooth, resembling those of the Opossum, but having the outer lobes of its crown proportionately better developed, and the intermediate ones reduced to a minute condition. The other specimen, an isolated tooth, is a reduced example of the former tooth. The larger tooth is 2 lines fore and aft and $2\frac{1}{2}$ lines transversely. The animal was about half the size of the Opossum.

TRIACODON, *Marsh.*

Triacodon fallax

Is the name given to another insectivorous mammal, by Prof. Marsh, from some remains found at Grizzly Buttes, Wyoming.

RODENTIA.

Judging from the number of fossils already found, the gnawing animals were abundant in the Bridger Tertiary fauna. None of them, thus far indicated, were remarkable for size, in comparison with those now living.

PARAMYS.

A genus apparently allied with that to which the Maryland Marmot belongs, and indicated by three portions of lower jaws belonging to as many distinct species. The specimens were discovered the last summer, in the vicinity of Fort Bridger, by Dr. Carter, and by him transmitted to the writer. The animals were no doubt powerful gnawers, as the incisor teeth are observed to extend far back in the jaw, not only beneath but also behind the grinders, as in the Beaver. The jaws are comparatively short and deep. The ridge defining the muscular fossa on the outer back part of the jaw is strongly pronounced, indicating powerful masticatory muscles. The molar teeth are four in number, and have a distinct enameled crown inserted by fangs, as in the squirrels and marmots. The triturating surface of the crowns is bounded by prominent angles, inclosing a cup-like hollow. The species are as follows:

Paramys delicatus.

The largest one, about one-fourth less than the Maryland Marmot. Length of the molar series of teeth, $\frac{3}{4}$ of an inch. Diameter of the incisors, $2\frac{1}{2}$ lines fore and aft and $1\frac{1}{2}$ lines transversely.

Paramys delicatior.

The second-sized species. The molar series is $7\frac{1}{2}$ lines long. The incisors are 2 lines fore and aft and $1\frac{1}{2}$ in transverse diameter.

Paramys delicatissimus.

The smallest species. Length of the molar series, $\frac{1}{2}$ inch. Diameter of the incisors, $1\frac{1}{2}$ lines fore and aft and 1 line transversely.

MYSOPS.

Mysops minimus.

A smaller rodent than any of the preceding, and not much larger than the Domestic Mouse, is indicated by a ramus of the lower law retaining a pair of molar teeth. The construction of the jaw and the number of grinders are the same as in *Paramys*, but the teeth present a different arrangement of the sculpturing of the crown. The penultimate molar in its worn condition presents a pair of transverse ellipses of dentine united by a median isthmus of the same substance and bordered with enamel. The crown of the last molar exhibits five shallow tubercles, with minute exposed islets of dentine at their summit. The length of the entire molar series is $\frac{1}{4}$ inch.

SCIURAVUS, *Marsh.*

Sciuravus nitidus; Sciuravus undans.

Two rodents, about the size of the Brown Rat, and probably belonging to the squirrel family, named by Prof. Marsh from some remains found at Grizzly Buttes, Wyoming.

ODD-TOED PACHYDERMS.

PALÆOSYOPS.

The most abundant of the mammalian remains pertaining to the Bridger Tertiary strata, judging from the fossils which have been brought to our notice, are those of a tapir-like animal about the size of the living Tapir of South America. It was first indicated by a few imperfect but characteristic specimens discovered during Prof. Hayden's expedition of 1870. Since then it has been more fully exemplified by numerous specimens, many of them in a fine state of preservation. Most of these were collected during the last summer at Grizzly Buttes, Henry's Fork of Green River, Lodge-Pole Trail, and other localities in the vicinity of Fort Bridger, Wyoming, by Dr. J. Van A. Carter and Dr. Joseph K. Corson, U. S. A., and by these gentlemen were partly presented to the Academy of Natural Sciences of Philadelphia, and in part obligingly presented to the writer or submitted to his examination. Prof. Marsh has also informed us that his party had collected many remains of the same animal in the same locality.

The specimens clearly establish *Palæosyops* as an uneven-toed pachyderm, with the skeleton constructed nearly as in the Tapir.

The thigh-bone possesses a third trochanter, as characteristic of the odd-toed pachyderms, including the Tapir, the Rhinoceros, and the Horse. The hind feet nearly repeat the construction of those of the Tapir.

The skull, with its large temporal fossæ, high and thick saggital crest, concave occiput, broad, convex face, resembled that of the related *Palæotherium* of the Eocene deposits of Europe. The teeth also agree in number and nearly in constitution with those of that animal. The number of teeth altogether appear to have been 44, consisting of 3 incisors, 1 canine, 4 premolars, and 3 molars to the series on each side, above and below. The teeth in each jaw form a nearly unbroken arch, intervals existing only sufficient to accommodate the passing of the points of the large and bear-like canines.

The true molars above and below have a resemblance to those of *Palæotherium*. In the crowns of the upper true molars the inner constituent lobes are more completely isolated from the outer ones than in that genus, and the bottoms of the transverse valleys are proportionately of less depth. The last upper molar of *Palæosyops* has but a single lobe to the inner part of the crown.

In *Palæotherium* the large premolars have the same form as the true molars, but are quite different in this respect in *Palæosyops*. In the former the crown of the upper premolars, except the first, is composed of four lobes, as in the succeeding molars. In *Palæosyops* the first premolar has a conical crown, the second has a bilobed crown, and the third and fourth have trilobed crowns.

The canines of *Palæosyops* are proportionately as large and of the same form as in the Bears. These teeth render it probable that *Palæosyops* varied its vegetable diet with the flesh of animals. In two specimens of upper jaws, containing complete series of molar teeth, the second premolar teeth differ so much, that had they been found as isolated

specimens, I think it probable that most naturalists would have been misled, and perhaps referred them to different genera. While I am not prepared to say that they may not indicate different species, all the other teeth are so nearly alike, in form and size, that I am disposed to view them as the same.

Different isolated specimens of teeth exhibit some range of variation in size of individuals of *Palæosyops*, a variation which might lead one to view the specimens as representing several species.

Nearly all the remains of *Palæosyops* submitted to my examination I have referred to a single species, with the following name:

Palæosyops paludosus.

The size of the species was about that of the living Tapir of South America. The length of the upper series of molar teeth is $5\frac{3}{4}$ inches; of the three true molars, $3\frac{1}{3}$ inches. The length of the lower series of molar teeth, in a specimen belonging to a different individual from that from which the former measurements were taken, is $6\frac{1}{3}$ inches; the true molar series is $3\frac{3}{4}$ inches.

Prof. Marsh has described a tooth which he refers to a smaller species, with the name of *P. minor*. I suspect, however, that the specimen really pertained to a smaller individual of the same.

Palæosyops major.

A large species of *Palæosyops*, about the size of the Indian Rhinoceros, is inferred to have existed, from a few imperfect fragments obtained, in the vicinity of Fort Bridger. They were discovered by Dr. Carter the last summer, and were presented by him to the Academy of Natural Sciences. In *Palæosyops paludosus* the lower three back molars occupy a space of $3\frac{1}{2}$ inches; in the larger species, *P. major*, the same teeth occupy a space of $4\frac{1}{2}$ inches.

TROGOSUS.

Among the fossils, from the Bridger Tertiary formation, brought to the notice of the writer there is the lower jaw of a remarkable animal, which would appear to be an odd-toed pachyderm allied with the Tapir, but associating characters which approach it to the gnawing animals. The specimen was discovered last spring, in association with remains of *Palæosyops* and those of a curious extinct turtle, in the vicinity of Fort Bridger, by Dr. J. Van A. Carter, and was obligingly presented to me by him. The jaw belonged to an aged animal, so that the usual distinctive characters of the molar teeth are for the most part obliterated as the result of attrition in mastication. The construction of the jaw, but especially the cutting-teeth, are quite sufficient to distinguish the animal from all its associates as well as from any other previously described. The number of molar teeth to the series is six if not seven, the imperfection at the fore part of the specimen not permitting of a more positive determination. The molar series was not widely separated from the front teeth as in the Rhinoceros, Mastodon, and the whole order of gnawers, but closely approached the position of the incisors, apparently so as to leave no space to be occupied with a canine tooth, unless it was a very small one. The true molars in their worn condition look as if they were nearly identical in form with those of *Palæosyops*.

The fore part of the lower jaw of *Trogosus*, or the Gnawing Hog, as I have named the animal, is occupied with a pair of large incisors, somewhat peculiar, but so nearly resembling the incisor teeth of the rodents

that had they been found isolated I should have been misled and considered them as such. These teeth curve from the jaw parallel with each other as in the gnawers, but they are separated from each other by an interval sufficiently large to be occupied by a pair of small teeth. The large incisors do not extend so far back in their sockets as in the rodents, and in this respect present a condition more like that in the Hog and Peccary.

The constitution of the large incisors of *Trogosus* resembles that in the gnawers, and as in these they apparently were provided with permanent dental pulps, so that they continued their growth and protrusion as they were worn away at the gnawing extremity. The fore part of these teeth is more convex than in rodents, and the enamel extends to a greater depth at the sides. They were also worn away in a somewhat different manner. In rodents the opposing incisors of the upper and lower jaw are worn off in a sloping manner from the enamel cutting-edge backward toward the sockets of the teeth. In *Trogosus* the worn slope of the lower incisors is not only directed backward and downward but also outward. This would indicate a divergence of the upper incisors, which no doubt hold a position, when the jaws are closed, exterior to that of the lower incisors.

Canine teeth appear not to have existed, at least none of any size or of importance as efficient organs in the dental series. In this respect *Trogosus* is like the Mastodon, the Elephant, the Rhinoceros, and the Hyrax.

Trogosus castoridens.

The species named from its incisors, recalling to mind the powerful cutting teeth of the Beaver, was a much larger and proportionately more robust animal than this. It was about the size of the White-lipped Peccary of Brazil. Extent of the series of six lower molars nearly 4 inches. Extent of the series of true molars, $2\frac{1}{2}$ inches. Depth of large incisors, fore and aft, 10 lines; breadth, half an inch.

Trogosus vetulus.

A second and smaller species is indicated by a portion of an incisor tooth, likewise discovered by Dr. Carter in the vicinity of Fort Bridger. The specimen, though a mere fragment, is quite characteristic, as it preserves the peculiar form and also the mode of wearing of the cutting extremity. The species was about two-thirds the size of the former one. The diameter of the incisor from before backward is 7 lines; transversely, 4 lines.

HYRACHYUS.

Among the most abundant mammalian remains of the Bridger Tertiary formation are those of a genus of odd-toed pachyderms, allied to the living Tapir, to which the above name has been given. The genus was first indicated by some imperfect remains obtained on Smith's Fork and Black's Fork of Green River, Wyoming, during Prof. Hayden's exploration of 1870. The specimens are noticed in Prof. Hayden's Preliminary Report of the United States Geological Survey of Wyoming, &c., 1871, p. 359. Since then, during the last summer, Dr. J. Van A. Carter discovered a number of more perfect specimens, characteristic of the genus, on Henry's Fork of Green River and at Bridger Butte, in the vicinity of Fort Bridger, Wyoming. Dr. Joseph K. Corson, U. S. A., has also collected additional material at Grizzly Buttes, Wyoming.

From the many specimens, consisting of portions of jaws with most of the teeth, together with other portions of the skeleton, which have

been kindly placed at our disposal by the gentlemen just named, we have been enabled more clearly to ascertain the relations of the genus.

Hyrachyus approaches nearly the extinct genus *Lophiodon*, first described by Cuvier from remains found in the earlier Tertiary formations of France and Germany. *Lophiodon* was closely related with the existing Tapir. It possessed six molar teeth, in both the upper and lower jaw, on each side. The Tapir has an additional tooth to the upper molar series. *Hyrachyus* has seven teeth to the molar series above and below, or seven above and six below, as in the Tapir.

In *Lophiodon* the last lower molar has a trilobed crown; in *Hyrachyus*, as in the Tapir, it has a bilobed crown. In the upper premolars of the Tapir, except the first one, the crown presents a distinct pair of inner lobes, connected by transverse ridges with the outer pair, as in the succeeding true molars.

In *Lophiodon* the upper premolars, except the first, have a single lobe to the inner part of the crown, associated by a single ridge with the anterior of the outer pair of lobes.

In *Hyrachyus* the two back upper premolars, corresponding with those of *Lophiodon*, have a single lobe to the inner part of the crown, associated by a pair of ridges with both of the outer lobes.

The canine teeth and the incisors of *Hyrachyus* hold the same relative position as and resemble those of the Tapir.

Hyrachyus agrarius.

The species thus named was about two-thirds the size of the South American Tapir. The molar series above and below contains seven teeth. A series of upper molars measures 3¾ inches. A lower jaw from another individual, from the back of the last molar to the chin, measures 5¼ inches. The molar series of the same specimen measures 3½ inches. Some remains from the same formation and locality, described by Prof. Marsh and referred by him to *Lophiodon Bairdianus*, probably belong to the same species.

A species originally inferred to exist from a jaw specimen of a young animal, and indicated in Prof. Hayden's preliminary report above mentioned, under the name of *Hyrachyus agrestis*, I now suspect to belong to the same species as the foregoing.

Hyrachyus modestus.

To a second species I now refer an upper molar tooth, obtained by Prof. Hayden near Fort Bridger, and mentioned in his last report under the name of *Lophiodon modestus.*

Hyrachyus eximius.

A larger species is inferred to have existed, from a small fragment of a lower jaw of a mature animal discovered by Dr. Carter in the vicinity of Fort Bridger. The specimen contains the last premolar and the succeeding true molar. The former tooth is 7¼ lines fore and aft; the latter 8½ lines. The depth of the jaw fragment is 1½ inches. The species was intermediate in size to *Hyrachyus agrarius* and the South American Tapir.

Hyrachyus nanus.

A smaller species than any of the preceding is indicated by two portions of lower jaws, one of which was obtained by Dr. Carter at

Lodge-Pole Trail, the other by Dr. Corson at Grizzly Buttes. The specimens belonged to mature animals, and both exhibit the molar series with six teeth as in *Lophiodon* and the Tapir. The last lower molar has a bilobed crown as in the latter animal.

The reduction in the number of premolars from four to three is probably the least important of the characters distinguishing the genera *Lophiodon*, *Tapirus*, and *Hyrachyus*.

Prof. Marsh has described the portion of an upper jaw containing seven teeth, which he refers to a species under the name of *Lophiodon nanus*. The specimen was found at Grizzly Buttes, and probably belongs to the species of *Hyrachyus* just described.

LOPHIODON.

Lophiodon affinis. Lophiodon pumilus.

Some remains, from the Tertiary of Wyoming, described by Prof. Marsh and attributed by him to two species of *Lophiodon* under the above names, may, in the discovery of more complete material, prove to belong to the former genus.

HYOPSODUS.

Among the pachyderms of the age of the Bridger Tertiary formation, there were several remarkable for their small size, none now being in existence so diminutive, nor, indeed, at any age, is there any evidence of smaller ones. Most of the fossil remains of these animals which have been submitted to my examination consist of portions of lower jaws with teeth. Portions of lower jaws in many formations appear to be among the most frequent of vertebrate fossils. This is due to the comparatively firm constitution of the lower jaw, and the readiness with which it becomes detached in the decomposition of an animal lying on a muddy bottom of some body of water. Once detached, it readily becomes imbedded in the mud and enshrined in the future rock. The more bulky head, remaining still longer exposed, is liable to be broken up and its fragments scattered.

Prof. Hayden, Dr. Carter, and Dr. Corson have collected many fragments of lower jaws with teeth, of a small pachyderm, at Black's Fork, Grizzly Buttes, Lodge-Pole Trail, and other localities in the vicinity of Fort Bridger, Wyoming, which I have referred to a genus with the name at the head of this chapter.

The lower-jaw specimens exhibit a continuous arch of teeth, composed on each side of seven molars, a canine, and, apparently, three incisors. None of the latter are retained in any of the specimens; and the same may be said of the canine, which is a comparatively small or feebly developed tooth. The first premolar is inserted by a single fang, which is, however, broad and apparently constituted of a connate pair. The other pre-molars, and the succeeding molars, have each a pair of fangs.

As characteristic of the genus, and distinguishing it from other small pachyderms with which it was associated, we may describe especially the first and second true molars of the lower jaw. These have an oblong crown of nearly uniform width, composed of an outer pair of demiconoidal lobes, of which the posterior is the larger, and an inner pair of conical lobes, of which the anterior is the larger. The summits of the outer lobes are crescentoid; those of the inner ones simply pointed. The contiguous horns of the inner crescentoid summits join the antero-internal lobe. The anterior horn of the anterior crescentoid summit

curves inwardly to the base of the antero-internal lobe. The posterior horn of the posterior crescentoid summit ends in a tubercle at the back of the crown, opposite the interval of the hinder pair of lobes.

Hyopsodus paulus.

The species was about the size of a Rabbit. Distance from the back of the last lower molar tooth to the chin is about 13 lines. Space occupied by the molar series, 11 lines; by the true molar series, $5\frac{3}{4}$ lines; and in another specimen, 6 lines. Depth of the lower jaw, from $3\frac{3}{4}$ to 4 lines.

A lower-jaw fragment, containing the last pair of molar teeth unworn, which I supposed to belong to another small pachyderm, to which I gave the name of *Microsus cuspidatus*, I now suspect to belong to the same animal as the former. The specimen was obtained by Prof. Hayden at Black's Fork, of Green River, Wyoming. The jaw is much more slender than in the more characteristic specimens referred to *Hyopsodus paulus.* Below the second true molar it is only 3 lines in depth, whereas in the latter specimens in the same position it is 4 lines. Perhaps the fragment may indicate another species.

MICROSYOPS.

Microsyops gracilis.

Another diminutive pachyderm, about the size of that just described, is indicated by several lower-jaw fragments, discovered last summer by Dr. Carter, at Grizzly Buttes and Lodge-Pole Trail. The specimens were accompanied with others, consisting of upper-jaw fragments with teeth, probably of the same animal, though it is not improbable they may pertain to *Hyopsodus paulus.*

Microsyops gracilis possessed larger canines, and one molar less to the series of the lower jaw than the last-named animal. Of incisor teeth or their sockets, no remains are preserved in the specimens.

The molar series is scarcely 10 lines in length, and the true molars occupy a half an inch of the space. The crowns of the latter teeth, except the last one, which has an additional lobe, are composed of four lobes, as in *Hyopsodus gracilis.*

The fore part of the crown of the first and second true molars is decidedly narrower than the back part. The inner lobes are proportionately smaller, compared with the outer ones, than in *Hyopsodus.* Of the diverging arms of the summit of the antero-external lobe, the front one terminates in a tubercle in advance of the antero-internal lobe, and the back one joins the latter. Of the diverging arms of the postero-external lobe, the front one ends at the bottom of the lobe in advance, and the back one terminates in a tubercle behind the interval of the posterior pair of lobes of the crown. The depth of the jaw at the middle true molar is $4\frac{1}{2}$ lines.

Prof. Marsh has described some remains from Grizzly Buttes, which he refers to a species with the name of *Hyopsodus gracilis.* These I suspect belong to the same animal.

The upper-jaw specimens alluded to at the beginning of this article are of a size to accord with those referred to *Microsyops gracilis.* Six upper molars occupy a space of three-fourths of an inch. The true molars occupy a space of 5 lines in one specimen and $5\frac{1}{2}$ lines in another.

The crowns of the upper true molars remind one of those of the extinct equine genus *Anchitherium.* The last premolar resembles that of a Deer, having a two-lobed crown. It and the premolar in advance are inserted with three fangs. The first premolar of the specimen was inserted by a pair of fangs.

NOTHARCTUS.

Notharctus tenebrosus.

This animal was inferred from a specimen consisting of a nearly complete ramus of a lower jaw with most of the teeth. The fossil was found imbedded in a grayish sandstone, at Black's Fork of Green River, during Prof. Hayden's exploration of 1870. In his "Preliminary Report" of last year I have placed it with the carnivora, but am now inclined to doubt whether this is its true position. Notwithstanding the carnivorous aspect of the canine tooth, I suspect the animal to have been a pachyderm; probably one of carnivorous habit.

The teeth, consisting of incisors, a canine, and seven molars, form together a nearly unbroken row. The canine has the ordinary form and proportions of that of most carnivorous animals.

In the original specimen the true molar teeth are much worn, so that the characteristic marks are obliterated. In several fragments of jaws, apparently of the same animal, obtained by Dr. Carter in the vicinity of Fort Bridger, the molars are less worn, and therefore exhibit some of the anatomical characters. In these specimens the first and second true molars have oblong crowns, constructed nearly as in *Hyopsodus.* As in this, the contiguous horns of the summits of the outer lobes of the crown join the antero-internal lobe. In advance of the latter are two small tubercles, the outer of which forms the termination of the anterior arm of the summit of the antero-external lobe. The characters of these teeth appear to agree with those assigned by Professor Marsh to a genus of pachyderms, which he has named *Limnotherium.*

The length of the dental series of the lower jaw of *Notharctus tenebrosus* is 19½ lines. The true molars occupy a space of 9 lines. The animal was about a third less in size than the Raccoon, with which I at first supposed it to be related.

Notharctus robustior. m. o. f.

A small fragment of a lower jaw, containing the perfect second true molar, with portions of the others, would appear to indicate a larger species of *Notharctus.* The specimen was obtained by Prof. Hayden's party, on Henry's Fork of Green River. The entire tooth has the same characters as the corresponding one of *N. tenebrosus.* It measures 3½ lines fore and aft and 2½ lines transversely. In *N. tenebrosus* the corresponding tooth measures in the same directions 2½ by 2 lines.

LIMNOTHERIUM, *Marsh.*

Limnotherium tyrannus. Limnotherium elegans.

Two pachyderms allied to the preceding, but of smaller species, named by Prof. Marsh from remains found in the Tertiary formation of Wyoming.

LOPHIOTHERIUM.

Lophiotherium sylvaticum.

Of this animal no additional remains have come under my notice since the description of the jaw fragment, discovered by Prof. Hayden, on Henry's Fork of Green River, in 1869. The animal was about a third less in size than the smaller living Peccary. The true molar series of the lower jaw occupies a space of 12½ lines.

Lophiotherium Ballardi.

A second and smaller species, named by Prof. Marsh, from a jaw fragment with teeth, found at Grizzly Buttes, Wyoming. The last lower molar tooth measures scarcely $4\frac{1}{2}$ lines fore and aft, whereas in the former species it measures $5\frac{1}{4}$ lines.

TITANOTHERIUM. (?)

Titanotherium (?) anceps.

Some remains of the largest mammal of the Bridger Tertiary formation have been referred with doubt by Prof. Marsh to the genus *Titanotherium*. The animal was about two-thirds the size of the *Titanotherium Prouti*, of the *Mauvaises terres* of White River, Dakota. Perhaps the remains I have referred to *Palæosyops major* may belong to the same.

EVEN-TOED PACHYDERMS.

ELOTHERIUM.

Elotherium lentis.

A species of suilline pachyderms, indicated by Prof. Marsh and founded on a jaw fragment containing a last molar tooth, from Henry's Fork of Green River, Wyoming. The species was about half that of *Elotherium Mortoni* of the *Mauvaises terres* of White River, Dakota.

PLATYGONUS.

Platygonus Ziegleri.

Another suilline pachyderm, indicated by Prof. Marsh, he refers to the Peccary-like genus above named. It is founded on specimens obtained at Grizzly Buttes, Wyoming. The species was as large as the Domestic Hog.

BIRDS.

Of remains of birds I have detected no trace of bones, among the collections of fossils, from the Tertiary formation of Wyoming, which have been submitted to my inspection.

Prof. Hayden exhibited to the writer an interesting specimen, consisting of the impression of the distal extremity of a feather in a fragment of shale, which was discovered among the Green River shales, so remarkable for the great number of well-preserved fishes they contain.

BUBO.

Bubo leptosteus.

Prof. Marsh, who has taken especial pains to seek for these rarest of fossils, the remains of birds, reports the discovery of some bones in the Tertiary beds of the Green River Basin. One of these, from Grizzly Buttes, he refers to an owl about two-thirds the size of the Great-Horned Owl. The species is named as above.

REPTILES.

CROCODILIA.

CROCODILUS.

When an isolated vertebra of a crocodile, from the Tertiary formation of Wyoming, was submitted to my inspection in 1868, it did not lead me to anticipate the many crocodilian remains which have since been discovered in the same Territory. No trace of crocodiles had previously been detected in the extensive Tertiary deposits of Dakota and Nebraska, which have yielded such a multitude of remains of mammals and turtles.

Crocodilus aptus.

A species named from a single vertebra, found by Col. John A. Knight, U. S. A., near South Bitter Creek, Wyoming. The animal was about the size of the Mississippi Alligator.

Crocodilus Elliotti.

A species assumed to be different from the former, and chiefly indicated by the greater part of a skull, broken into fragments, found on one of the tributaries of Green River, Wyoming, during Prof. Hayden's exploration of 1870. The skull is about a foot and a half in length, and has nearly the shape of that of the existing Crocodile of the Nile.

Many additional remains of crocodiles obtained by Drs. Carter and Corson, in the vicinity of Fort Bridger, Wyoming, have been sent to me. Among these there is a nearly complete lower jaw, which was discovered by Dr. Corson, imbedded in a green sandstone. I am uncertain whether it pertained to the species just indicated.

Prof. Marsh has collected a number of remains at Grizzly Buttes and other localities in the neighborhood of Fort Bridger, which he attributes to four species distinct from those above named. They are noticed in the American Journal of Science and Arts for 1871, under the names which follow:

Crocodilus ziphodon.

A comparatively small animal in its family, and judging from the characters of the teeth not a true crocodile.

Crocodilus liodon.

Crocodilus affinis. Crocodilus Grinnelli.

CHELONIA.

TESTUDO.

Testudo Corsoni.

Dr. Joseph K. Corson, U. S. A., stationed at Fort Bridger, in the intervals of his professional duties, directs his attention to the investigation of the natural resources of the country. One of the results of his explorations is the discovery of many interesting fossils of the Bridger Tertiary formation, specimens of which we have had frequent occasion to mention. Among the fossils found by him last summer, and presented to the Academy of Natural Sciences of Philadelphia, is the fore part of a plastron of a huge land-turtle, equal to the largest

now in existence; that is to say, the great land-tortoise of the Gallipagos Islands. The species was named in honor of its discoverer.

EMYS.

Emys wyomingensis.

The most abundant remains of turtles of the Bridger Tertiary formation which have come under the notice of the writer are those of a species of *Emys* to which the above name was originally given. Many specimens of shells, some of them nearly perfect, have been submitted to my examination by Dr. Carter, Dr. Corson, and Prof. Hayden Fragments of shells of this species, sent to me by Dr. Carter in 1868, were among the first fossils I had seen from the Tertiary formation of Wyoming.

The first specimens examined exhibited sufficient variation to lead me to refer them to several different species under the additional names of *Emys Stevensonianus*, *E. Haydeni*, and *E. Jeanesi*. Additional specimens, of different ages, from a young one about the size of the palm of the hand, to those which had reached maturity and are a foot long, and are three-fourths of a foot broad, led me to view all as pertaining to a single species. Every specimen exhibits some variation, so that following the original plan, they would indicate a dozen species.

The form and constitution of the shell of *Emys wyomingensis*, as well as the impressions of the horny scales, are the same as in living species of terrapenes.

Emys Carteri.

Dr. J. Van A. Carter, who has pursued the investigation of the Bridger Tertiary formation with untiring industry and zeal, the last summer, sent to the Academy of Natural Sciences of Philadelphia the remains of one of the largest known species of terrapenes; the specimen consisting of the greater portion of the plastron or under shell, and the fore part of the carapace or upper shell. Dr. Carter discovered it imbedded in a green, friable sandstone in the vicinity of Fort Bridger. In its complete condition this turtle has measured about two and a half feet in length. The plastron is 2 feet long. The first vertebral plate is clavate in outline, and 4 inches in length. The first vertebral scute is vase-like in its form, and is 5½ inches in its fore and aft diameter. The species has been named in honor of its discoverer.

BAPTEMYS.

Baptemys wyomingensis.

A peculiar and interesting extinct genus of turtles, pertaining to the Bridger Tertiary formation and named as above, appears to be intermediate in character to the living genera *Dermatemys* and *Staurotypus*. It was one of the earlier described animals from the Tertiary formation of Wyoming, and was first indicated by a well-preserved and nearly complete shell discovered in the vicinity of Fort Bridger by Mr. O. C. Smith. A second less complete specimen was obtained at Grizzly Buttes during Prof. Hayden's exploration of 1870.

The carapace, or upper shell, is oval in outline, and resembles in shape and constitution that of *Dermatemys*, a large, living fresh-water turtle of South America. The plastron, or lower shell, partakes more of the character of that of *Staurotypus*.

Compared with ordinary terrapenes, the intervals between the upper and lower shells on each side are proportionately very large, more as in the condition of the snappers.

The bridges connecting the plastron and carapace are intermediate in their proportions to those in *Dermatemys* and *Staurotypus*, and the same may be said in relation with the common terrapenes and the snappers. They are impressed by a row of three large scales between the position of the usual scute impressions of the plastron and those of the border of the carapace.

The fore extremity of the plastron is nearly like that in *Dermatemys*, but is widely emarginate at the end, and is obtusely rounded at the border instead of being acute as usual in terrapenes. The hinder extremity of the plastron is narrower proportionately than in *Dermatemys*, but wider than in *Staurotypus*, and it ends in a rounded manner.

The first pair or gular scute impressions of the plastron as existing in ordinary terrapenes appear to be absent in *Baptemys*, or rather they are not distinct from the humeral scute impressions.

The shell of *Baptemys wyomingensis* is about $1\frac{1}{2}$ feet in length and 1 foot in breadth. The plastron is rather less than 1 foot in length; its breadth to its junction with the carapace 9 inches; and the fore and aft extent of its bridges $4\frac{1}{2}$ inches.

Baptemys is nearly related to the extinct genus *Pleurosternon* of the English Tertiary.

BAENA.

Baena arenosa.

The extinct genus of turtles, *Baena*, was originally indicated by a nearly complete shell, discovered during Prof. Hayden's expedition of 1870, in the vicinity of Fort Bridger, Wyoming. Another shell, discovered by Dr. Carter in the same locality, and presented to the writer, from some variation, was supposed to indicate a second species of the same genus. The two were named *Baena arenosa* and *B. affinis*. Additional specimens exhibiting some variation of character lead me to suspect that these are the same.

The specimens generally have been so much crushed downward that it is difficult to form an estimate of the degree of convexity or prominence of the shell of *Baena arenosa*. It would appear to be rather compressed, or about as prominent as in the ordinary Snapper. It partakes of characters of the latter, the terrapenes, and the sea-turtles.

In all the specimens the bones which compose the shell are completely co-ossified, so that the sutural connections cannot be followed.

The upper shell is broadly oval, and is notched behind as in the Snapper. The under shell is flat and more like that of a terrapene in appearance than that of the Snapper. The bridges connecting the two shells are relatively as wide as in the former but are longer. The ends of the plastron are tongue-like and feebly emarginate.

The number and arrangement of the horny scales of the carapace appear to be the same as in the terrapenes and snappers. The scales of the plastron consist of seven pairs, besides additional ones to the bridges, as in the latter and the sea-turtles.

The shell of *Baena arenosa* was a little over a foot in length and three-fourths of a foot in breadth.

Baena undata.

Last summer Dr. Carter sent, as a gift to the Academy of Natural Sciences of Philadelphia, the greater part of a shell of a large turtle which he discovered in the vicinity of Fort Bridger. Its interior is occupied with a greenish-gray sandstone. The specimen I suppose to belong to the same genus as those just indicated. It belonged to a much larger species than the former, and in its perfect condition measured about a foot and a half in length and is a foot and a quarter in breadth.

The great strength of the shell has apparently prevented its being crushed by the superincumbent strata beneath which it was imbedded. The shell consequently appears much more vaulted than in the preceding species.

The upper shell or carapace is sustained by strong, vertical plates extending from the plastron at the bottom of the notches between the two. These plates project so far into the interior of the shell as to appear like partitions, dividing it into three compartments communicating through the partitions. A similar arrangement exists in the Batagur, a curious genus of fresh-water turtles living in India.

As in the specimens of *Baena arenosa*, that of *B. undata* has its constituent plates co-ossified, though not to such a degree as to obliterate the course of all the sutures. The visible course of these in the plastron enables us to detect an unusual arrangement of the plates. Between the two middle pairs of osseous plates as existing in most living and other known extinct turtles, there is intercalated an additional pair of plates. These are triangular with their apices, conjoined at the center of the plastron, and the bases directed outwardly and joining the marginal plates of the shell at the intermediate half of the bridge joining the plastron to the upper shell.

A similar pair of intercalated plates exists in the genus *Pleurosternon*, an extinct turtle of the early Tertiary formation of England; but in that genus they form parallelograms, and thus accord more with the ordinary form of the including plates, as in turtles generally.

The bridges of the plastron exhibit four large scutal impressions, as in one of the most perfect specimens of the shell of *Baena arenosa*.

The costal scute areas of the carapace are defined from the marginal scute areas by a remarkable serpentiform groove. The medial groove of the plastron likewise presents this serpentiform character. From this tortuous course of the grooves just mentioned, the species has received its name.

HYBEMYS.

Hybemys arenarius.

A small extinct turtle is indicated by some small imperfect fragments, obtained during Prof. Hayden's exploration of 1870, in a Tertiary deposit on Little Sandy Creek. The most characteristic specimen consists of an isolated marginal bone, which resembles in form, and the impressions produced by the investing horny scales, a corresponding lateral plate of the upper shell of an ordinary terrapene. The fore and back parts of the plate exhibit a half-circular, convex boss, indicating the carapace to have been encircled with a row of hemispherical protuberances, unlike anything noticed in previously described turtles. The species was about the size of our common Speckled Terrapene, *Emys picta.*

ANOSTEIRA.

Anosteira ornata.

An extinct genus of turtles, different from any of the preceding, is indicated by many fragments of shells of a small species, obtained by Prof. Hayden and Dr. Carter at Church Buttes, Grizzly Buttes, and other localities in the vicinity of Fort Bridger.

The shell is moderately compressed, broad and ovoid; in outline intermediate in form with that of the terrapenes and the sea-turtles. The fore part of the carapace is deeply and widely notched; the back part is expanded and obtuse. The marginal plates are joined by a continuous suture with the costal plates, as in the terrapenes. The surface of the carapace is conspicuously ornamented with closely crowded tubercles, which are round or in the form of short ridges. No impression of horny scutes is visible on the bony plates, so that in this respect, and the ornamentation of the surface, the carapace is like that of the soft-shell turtles or *Trionyces*. The plastron is small in its relation with the upper shell, as in the Snapper; and it firmly articulates with it by bridges which are proportionately much wider than in the latter. The back end is narrow, the fore end of greater width. The nuchal plate of the carapace is even, but the last vertebral and the pygal plates are sharply carinate. The shell of *Anosteira ornata* was about 5 inches in length.

TRIONYX.

Trionyx guttatus.

An extinct species of soft-shelled turtle belonged to the Bridger Tertiary period. It is indicated by many fragments of shells, which have accompanied nearly every collection of fossils from Wyoming, submitted to my inspection. The best specimen is the one from which the species was originally described, discovered at Church Buttes during Prof. Hayden's exploration of 1868. The osseous carapace, or upper shell, has measured about 14 inches in length, and upward of a foot in breadth.

Fossil turtle-eggs.

Last summer Dr. Carter sent me numerous elongated, elliptical bodies, which he had discovered in various places in the vicinity of Fort Bridger. These, he observed, he thought might be the fossil eggs of some animal, and, in fact, I suspect them to be fossil turtle-eggs. They present two sizes, each being quite uniform. They have the same form as the eggs of living terrapenes, but are smaller than those of our smallest species.

LACERTILIA.

SANIVA.

Saniva ensidens.

As members of the Tertiary fauna of Wyoming, there were a number of lizards related to the living Monitors and Iguanas. The remains of one of these animals, consisting of portions of a skeleton imbedded in an ash-colored rock, were discovered near Granger, Wyoming, during Prof. Hayden's exploration of 1870. They indicate an animal as large as the common Iguana of South America, or one as large as any now in

existence. Imbedded in the same rock, in close proximity to the bones of the skeleton, there was detected an isolated tooth, which is supposed to belong to the same animal. The tooth is compressed conical, and curved, and has its borders quite sharp.

Since describing these remains, and referring them to an extinct genus and species under the name of *Saniva ensidens*, in breaking open some portions of the rock containing the remains of the skeleton, a fragment of the upper jaw has been detected, evidently forming part of the latter. The teeth contained in the fragment are imperfect, but are sufficiently well preserved to indicate a shape different from the isolated tooth above mentioned. Their form is more like those of the living Iguana, but they are not serrated. The isolated tooth is like those of the Monitor. No traces of scales were found imbedded in the rock in association with the bones.

GLYPTOSAURUS, *Marsh.*

During the last summer Dr. Carter sent to me a number of detached vertebræ and fragments of other bones, found in the vicinity of Fort Bridger, which resemble those of the skeleton of *Saniva ensidens*. These were accompanied with a number of osseous scales, resembling those of the living armadillos. Similar scales, from the same locality, have been described by Professor Marsh, and referred to a lacertilian with the above name. From the difference in ornamentation of the scales and other characters, the remains he attributed to four different species under the following names:

Glyptosaurus sylvestris. *Glyptosaurus nodosus.* *Glyptosaurus ocellatus.* *Glyptosaurus anceps.*

OPHIDIA.

Among other reptilian remains obtained from the Tertiary formation in the vicinity of Fort Bridger, Wyoming, are those of a number of snakes described by Prof. Marsh. Most of the specimens, he informs us, "belonged to constricting serpents, closely related to the modern Boas of South America, although considerably smaller and generically distinct. A few of the specimens indicate snakes of moderate size, with apparently quite different affinities." Prof. Marsh refers the remains to no less than five species of there extinct and peculiar genera, which he names as follows:

BOAVUS, *Marsh.*

Boavus occidentalis. *Boavus agilis.* *Boavus brevis.*

LITHOPHIS, *Marsh.*

Lithophis Sargenti.

LIMNOPHIS, *Marsh.*

Limnophis crassus.

FISHES.

The Green River shales, in one locality on the line of the railroad, teem with such a profusion of well-preserved fishes that the place has been named the Petrified Fish Cut. The formation and fishes are probably of cotemporaneous age with the formation and its remains of other vertebrates, indicated in the preceding pages. It was one of these fossil fishes, obtained in this locality in 1856 by Dr. John E. Evans, and

submitted to the writer for examination, that has proved to be the forerunner of our knowledge of the Tertiary fauna of Wyoming, as developed in these pages.

CLUPEA.

Two species of the genus, to which belong our Shad and Herring, have been detected in the Green River shales.

Clupea humilis.

A small species, the one above referred to as being the first fossil discovered in the Tertiary formation of Wyoming. It is very abundant in the Green River shales, and measures $3\frac{1}{2}$ inches in length.

Clupea pusilla.

A species about half the size of the preceding, described by Prof. Cope.

OSTEOGLOSSUM.

Osteoglossum encaustum.

Three to four feet in length. Described by Prof. Cope.

ASINEOPS, *Cope.*

Asineops squamifrons. Asineops viridensis.

Two species of a peculiar genus, described by Prof. Cope.

ERISMATOPTERUS, *Cope.*

Erismatopterus Rickseckeri.

A cyprinodont fish, 3 to 4 inches in length, of a peculiar genus, described by Prof. Cope.

LEPIDOSTEUS.

Lepidosteus glaber. Lepidosteus Whitneyi.

Two species of bony-gars, indicated by Prof. Marsh.

AMIA.

Amia Newberrianus. Amia depressus.

Two species of mud-fish, indicated by Prof. Marsh.

PRELIMINARY LIST OF THE FOSSILS COLLECTED BY DR. HAYDEN'S EXPLORING EXPEDITION OF 1871, IN UTAH AND WYOMING TERRITORIES, WITH DESCRIPTIONS OF A FEW NEW SPECIES.

BY F. B. MEEK.

SILURIAN FOSSILS.

1. *Halysites catenularia*, Linn., (sp.); Box Elder Cañon.

CARBONIFEROUS FOSSILS.

2. *Zaphrentis;* Bridger's Butte.
3. *Zaphrentis ? Stansburyi*, Hall; Red Rock Creek, Twin Springs, Dry Creek Valley.
4. *Lithostrotion ?;* Twin Springs.
5. *Syringopora;* head of Alder Gulch, Virginia City.
6. *Syringopora;* half-way between Mantua and Cache Valley.
7. *Rhombopora;* Twin Springs.
8. *Chætetes;* divide near Junction.
9. *Platycrnites (Eucladocrinus) Montanaesis*, Meek.

Body subovoid, a little higher than wide, the widest part being above. Base basin-shaped, forming nearly one-third the height of the body, rounded to the column below. First radial pieces, a little longer than wide, with the widest part above, oblong-subquadrangular in general outline, but having the superior lateral angles apparently a little truncated, and the lower edge convex in outline, while the upper margin has a moderately deep sinus, equaling about one-third its breadth, for the reception of the next radial. Second radial piece very short, almost subtrigonal, with lateral angles a little truncated, and bearing on its upper, sloping sides the first and only divisions of the rays, which do not properly bifurcate again, but continue like free, simple arms, composed each of a single series of short, more or less wedge-formed pieces, every second one of which gives off at its larger end (alternately on opposite sides) a true arm. Arms very numerous, rounded on the dorsal side, and composed each of two ranges of alternating and interlocking small pieces that bear the pinnules (tentacula of some) on their inner side. Surface smooth. (Vault unknown.)

This species is very peculiar in having the rays, after the first division on the second radials, simple, or without further division, and continued by a direct succession of a single series of pieces. These divisions of the rays, although long, free, and arm-like, are not true arms, because they each bear on each side a row of arms that are, as usual in the genus, composed of double rows of interlocking pieces, and support delicate pinnules, or tentacles, on the inner side. It is probable that the ambulacral furrows of these divisions of the rays are covered above by small pieces all the way out. If so, the species would bear exactly the same relations to *Platycrinites* proper, that *Steganocrinus* bears to *Actinocrinites*. Consequently, I propose to designate it as the type of a section, under the

name *Eucladocrinus*, in allusion to its very numerous branches or arms, of which there must be not less than 160 to 200 in the entire series.

10. *Crinoid fragments;* Twin Springs, Sage Creek, Montana; and Bridger Butte, near Fort Ellis.
    These fragments probably belong to several species of different genera.
11. *Polypora;* Twin Springs and Junction Divide.
12. *Fenestella* (allied to *F. multiporata*, McCoy); Devil's Slide and head of Black-Tail Deer Creek, Montana.
13. *Fenestella* (two or three species); near Junction Divide.
14. *Ptylopora;* Devil's Slide, Montana.
15. *Ptylopora;* Devil's Slide, Montana.
16. *Hemipronites* (either *H. crassius*, or *H. crenistria*); mountain, near Junction Divide, head Medicine Bow Creek, and Bear River Mountains, opposite Randolph.
17. *Chonetes;* Twin Springs.
18. *Productus punctatus*?; head of Alder Gulch, Virginia City, Motana.
19. *Productus;* head of Black-Tail Deer Creek.
20. *Productus* (fragments of a very finely striated species); Dry Creek.
21. *Productus longispinus*, Sowerby ?; Junction Divide.
22. *Productus;* half-way between Mantua and Cache Valley. (*22)
23. *Productus semireticulatus*, Martin; mountains near Junction Divide, head of Medicine Creek.
24. *Rhynchonella;* mountains near Junction Divide, head of Medicine Creek.
25. *Athyris subtilila*, H. ?; mountains near Junction Divide.
26. *Spirifer* (a large species like *S. Logani*, Hall); Medicine Lodge Creek, near Divide.
27. *Spirifer* (a smaller species, more extended on hinge-line); half-way between Mantua and Cache Valley. (*27)
28. *Spirifer;* Bridger's Butte, near Fort Ellis.
29. *Spirifer (Martinia)*, like *M. contracta*, M. & W.; half-way between Mantua and Cache Creek. (*29)
30. *Spiriferina*,? (like *S. octoplicata*, Sow.); Twin Springs.
31. *Euomphalus;* Twin Springs.

JURASSIC SPECIES.

1. *Rhynchonella;* shore of lake, twelve miles from Fort Ellis.
2. *Lingula;* Lincoln Valley, near Fort Hall.
3. *Ostrea* (mere fragments); Lincoln Valley, near Fort Hall.
4. *Gryphæa* (small, imperfect specimen); Lincoln Valley, near Fort Hall.
5. *Camptonectes bellistriata*, M. & H.; shore of lake, twelve miles from Fort Ellis.
6. *Entolium cingulatus*, Phillips ? (sp.); shore of lake, twelve miles from Fort Ellis.
7. *Gervillia* (an imperfect valve); shore of lake, twelve miles from Fort Ellis.
8. *Aviculopecten* (*Pseudomonotis* ?) *Idahoensis*, Meek.
    Shell suborbicular, very slightly oblique; hinge distinctly shorter than the valves. Left valve rather compressed; posterior ear very short or nearly obsolete, and scarcely angular at the extremity, the posterior margin below being convex in

* These may possibly be Devonian.

outline, instead of sinuous; anterior ear longer and more angular, compressed, but more distinct from the slight swell of the umbo than the other, and having its margin below broadly and rather slightly sinuous; surface ornamented by compressed, generally simple, alternately smaller and larger radiating costæ, only the latter of which reach the beak, while those of both series become nearly or quite obsolete on the ears, particularly on the posterior one; lines of growth small, rather regular and obscure. (Right valve unknown.)

This is probably neither a true *Pseudomonotis*, nor an *Aviculopecten;* but as I know nothing of the nature of its hinge, nor of its right valve, its true generic characters remain doubtful. Many paleontologists refer such forms to the genus *Pecten*, but they are evidently distinct from that group as typified by the existing *P. maximus*. Lincoln Valley, near Fort Hall, Idaho.

9. *Pinna* (a smooth attenuated species); shore of lake, twelve miles from Fort Ellis.
10. *Modiola;* same as last.
11. *Myacites* (*Pleuromya*)*;* same as last.
12. *Pholadomya;* same as last.

There are in the collection imperfect casts of several other bivalves from the Jurassic beds; but they are not in a condition to be referred to the proper genera.

CRETACEOUS SPECIES.

1. *Ostrea glabra*, M. & H.?; Point of Rocks, Union Pacific Railroad, Wyoming; from above a coal-bed.
2. *Ostrea Idriaensis*, Gabb ??; Point of Rocks, Union Pacific Railroad, Wyoming; from above a coal-bed.

   This is a rather large compress, moderately thick, subovate, or ovate-subtrigonal species, with more or less pointed, undistorted beaks, a comparatively small ligament area, a nearly flat upper valve, and a shallow lower one. In the latter the ligament area has a rather deep, mesial furrow, while the corresponding ridge in the area of the other valve is usually quite prominent at its inner end. The surface of both valves is only marked by distinct, more or less imbricating laminæ of growth.

   I have had specimens of this species under consideration, among the collections brought in by different exploring parties, for some years past, but I have never been able to arrive at a satisfactory conclusion in regard to it. It seems to be related to *O. Idriaensis* and *O. Breweri* of Gabb, but I am by no means sure that it belongs to either of them. If distinct, it may be called *O. Wyomingensis*.
3. *Ostrea* (fragments); mouth of Warm Spring Creek.
4. *Anomia ? gryphorhyuchus*, Meek; Point of Rocks, Wyoming.

   Shell small, rather thin, not very distinctly pearleaceous, ovate to suborbicular in outline. Upper valve, very convex and evenly rounded; beak marginal, prominent (the whole valve tapering toward it), and curved upward; surface, smooth, or sometimes showing faint traces of radiating striæ; muscular impression, very obscure; lower valve unknown.

   This little shell rarely attains more than three-quarters of an inch in length, with a breadth of about 0.60 inch, and a depth of 0.33 inch. Some examples are proportionally wider and less

convex. I am not sure that it is a true *Anomia*, as its form is rather unusual for a species of that genus, being more like that of *Ostrea* or *Gryphæa*, to one of which it may possibly belong; in which case the valve I have described as the upper would be the lower. I should have referred it to one of these genera, but for the fact that it seems to be entirely without a cardinal area, and the casts of the interior show no traces of the muscular cicatrix, usually so well defined in those genera. It is quite common, and all the specimens are convex valves.

5. *Inoceramus* (one or two species); Coalville, Utah.
6. *Inoceramus* (somewhat like *I. problematicus*); between Evanston and Fort Bridger.
7. *Cardium curtum*, M. & H.; between Evanston and Fort Bridger.
8. *Cardium pauperculum*, Meek; Medicine Bow, Wyoming Territory.
9. *Corbula*?; Coalville, Utah.
10. *Euspira*?; Coalville, Utah.
11. *Melanopsis*?; Coalville, Utah.
12. *Potamides*?; Coalville, Utah.
13. *Goniobasis*?; Coalville, Utah.

There are several other univalves and some bivalves in the collection from Coalville that appear to be marine and brackish water types; but as they are imperfect specimens, imbedded in a hard, gritty matrix, I have not had time to work them out so as to determine their affinities, and consequently have not included them in the list.

TERTIARY SPECIES.

1. *Corbula pyriformis*, Meek; Bear River City, west side of middle fork of Warm Spring Creek.
2. *Corbula Engelmanni*, Meek; Bear River City.
3. *Unio priscus*, M. & H.
4. *Unio Danæ*, M. & H.?; Fort Steele, Wyoming Territory.
5. *Corbicula (Veloretina) Durkeei*, Meek.
6. *Viviparus (Campeloma) macrospira*, Meek.
7. *Pyrgulifera humerosa*, Meek.
8. *Planorbis (Menetus)*; Bear River, 3 miles from Soda Springs.

The condition of most of the fossils enumerated in the foregoing list is such, that from a mere preliminary examination, it is scarcely possible, in a majority of cases, to do more than refer them to their proper genera. The Carboniferous forms are especially difficult to make out, the specimens being generally in a fragmentary condition, and imbedded in a very hard matrix that renders it almost impossible to work them out. With a few exceptions, however, all of the collections can be referred with confidence to their proper geological horizons.

The occurrence of *Halysites catenularia* in some of the lower beds at Box Elder Cañon, for instance, shows that some of these beds belong to the Silurian system; while those referred to the Carboniferous are such types as are alone found in rocks belonging to that period, with possibly the exception of a few from a locality half-way between Mantua and Cache Valley, which may prove to be of Devonian age, though I think them more probably Carboniferous. The larger portion of these Carboniferous forms also seem to be most nearly allied to species found in the upper members of the Lower Carboniferous of the Mississippi Valley; but some of them, particularly the *Polyzoa*, are very closely allied to forms found in the Coal-Measures in some of the Western States.

The Jurassic fossils in the collection are not numerous, nor in a very good condition, but they can readily be connected by the presence of

Camptonectes bellistriata, with beds at the Red Buttes on North Platte, and near the southwest base of the Black Hills, containing well-marked Jurassic forms; while the other forms found associated with this *Camptonectes* are quite unlike species found in any other than the Jurassic beds of the far West.

The Cretaceous fossils of the collection are, like the others, generally in a bad state of preservation. Those from Coalville, however, are quite interesting, because they come from very near the junction of apparently the Upper Cretaceous and the Lower Tertiary, and seem to consist of a mixture of Cretaceous and Tertiary forms, or at least of species most nearly allied to forms belonging to these horizons; while a few of them appear to be fresh and brackish water types, directly associated with *Inoceramus*, *Ostrea*, *Anomia*, *Euspira*, or *Natica*, and other marine types. The univalves are unfortunately too much broken and imbedded in the hard, gritty matrix to show clearly the forms of their apertures; but some of them seem to resemble very closely species of *Goniobasis* found in the fresh-water Tertiary beds of that region. These, however, may possibly prove to belong to some marine genus. There are also among them some very imperfect specimens that have much the general appearance of *Melanopsis*, and a bivalve very like *Corbicula cytheriformis*, M. & H. Without a more careful study, and the devotion of more time to working these specimens out of the matrix than circumstances will just now permit, it would be unsafe to speak positively in regard to the affinities of the species that do not seem to be strictly marine types. If any of them are fresh or brackish water forms, of course they must have been carried by streams, or other agencies, from their proper stations, and deposited in neighboring bodies of salt-water in which the marine forms lived and died. It might be urged, however, that the deposit is really a brackish-water Tertiary formation, of the earliest Eocene age, and that the Cretaceous marine forms belong properly to accidentally intermingled fragments of Cretaceous beds. The nature of the matrix and the exactly similar state of preservation of all of these fossils, as well as the proportionally larger number of the marine species, seem to me to show that they really belong to one and the same geological formation and lived at the same time.

I can see no good reason why there might not have been living in the streams and estuaries of the closing period of the Cretaceous age, and while Cretaceous types were still existing in the seas, a few fresh and brackish water species that continued to live and multiply during the earlier part of the Tertiary age. It is evident, however, from these and other collections brought by Mr. King from these beds, that there is a gradual passage from the Upper Cretaceous into the Lower Tertiary in this region; and that, unless the fossils from each subordinate seam or layer are kept carefully separated, and very minutely detailed local sections are taken, it will not always be easy to determine, at localities where the two groups meet, exactly where the line should be drawn between the Cretaceous and Tertiary; or, in other words, to separate, in all cases, the Cretaceous from the Lower Tertiary forms collected at such places.

All the undoubted Tertiary species in the collection are fresh and brackish water types of the oldest Eocene age, being species previously known from rocks of that age in this region.

In addition to the few new species that are here indicated, there are some other undescribed species in the collection that I have not yet had time to study with sufficient care to determine their affinities; and these have been left for future consideration.

PART IV.

ZOOLOGY AND BOTANY.

I.—ZOOLOGY.

I.—NOTICE OF SOME WORMS COLLECTED DURING PROFESSOR HAYDEN'S EXPEDITION TO THE YELLOWSTONE RIVER IN THE SUMMER OF 1871.—BY PROF. JOSEPH LEIDY.

II.—COLEOPTERA.—BY GEORGE H. HORN, M. D.

III.—NOTICES OF THE HEMIPTERA OF THE WESTERN TERRITORIES OF THE UNITED STATES, CHIEFLY FROM THE SURVEYS OF DR. F. V. HAYDEN.—BY P. R. UHLER.

IV.—NOTES ON THE SALTATORIAL ORTHOPTERA OF THE ROCKY MOUNTAIN REGIONS.—BY PROF. CYRUS THOMAS.

V.—LIST OF SPECIES OF BUTTERFLIES COLLECTED BY CAMPBELL CARRINGTON AND WILLIAM B. LOGAN, OF THE EXPEDITION, IN 1871.—BY W. H. EDWARDS.

VI.—REPORT ON THE RECENT REPTILES AND FISHES OF THE SURVEY, COLLECTED BY CAMPBELL CARRINGTON AND C. M. DAWES.—BY E. D. COPE, A. M.

II.—BOTANY.

VII.—CATALOGUE OF PLANTS.—BY PROF. THOMAS C. PORTER.

VIII.—MUSCI.—DETERMINED BY LEO LESQUEREUX, ESQ.

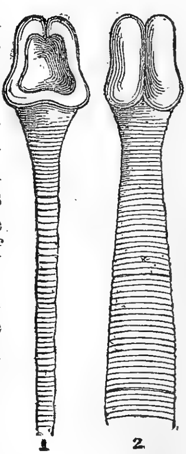
ZOOLOGY AND BOTANY.

NOTICE OF SOME WORMS COLLECTED DURING PROFESSOR HAYDEN'S EXPEDITION TO THE YELLOWSTONE RIVER IN THE SUMMER OF 1871.

BY PROF. JOSEPH LEIDY, OF PHILADELPHIA.

Among other interesting observations and discoveries made incidentally to the chief ones of Prof. Hayden's recent geological exploration of the country of the head-waters of the Yellowstone River, he reports that the Trout, which abounds in Yellowstone Lake, is greatly infested with a species of tape-worm. A number of the worms were collected by his assistant, C. Carrington, and submitted to my examination; but, unfortunately, the abundance of specimens placed in alcohol so much diluted it as to cause the decomposition of nearly all.

In Mr. Carrington's notes accompanying the specimens, he observes that the smaller worms were contained in cysts adherent to the exterior of the intestines, but the larger ones, up to six inches in length, were found imbedded in the flesh. From five to fifty of the parasites were found in a fish. When numerous they appeared to affect the health of their host, and the fishes most infested could generally be told by their duller colors, meagerness, and less activity. Mr. Carrington also states that the trout is not infested in the same manner in the Yellowstone below the upper falls.



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Among the specimens submitted to me were several of the worms inclosed in oval sacs imbedded in fragments of flesh. The sacs having remained unopened preserved the contained parasite from the general decomposition of the others, so as to enable me to ascertain its character. It belongs to the genus *Bothriocephalus*, or rather to that section of it now named *Dibothrium*. Two species have long been known as parasites of the Salmon and other members of the same genus of fishes in Europe, but the tape-worm of the Yellowstone trout appears to be a different one.

Two of the best preserved specimens of the tape-worm measure five inches in length by a line in width at the broadest part. The head, almost a fourth of a line in diameter, is obcordate, as represented in the magnified figures subjoined. The two bothria, or suckers, are thick and discoidal, placed back to back, obcordate in outline, and directed with their broad and slightly depressed surface toward the margin or narrower diameter of the body. The body is flat, thick, with rounded margins, and is narrowly annulated. The annulations appear due to muscular bands, and number about ten to the line. If other segments exist, independent of these annulations, as a character of the worm, the condition of the specimens does

not allow of their distinction from transverse fractures at irregular distances. No genital apertures could be detected at the sides or at the margins. Internal organs of any kind could not be seen, but the soft interior tissue of the body is filled with round corpuscles resembling in appearance starch-granules. These proved to be composed of carbonate of lime, as they were completely dissolved by acetic acid, with the evolution of carbonic acid. From the shape of the head this tape-worm might appropriately be named *Dibothrium cordiceps.*

A multitude of leeches were collected during Prof. Hayden's expedition, by two of his assistants, Messrs. Carrington and Dawes, from a lake in Wyoming Territory. These appear to belong to the species discovered by the writer several years since in Twin Lake, Minnesota, and described under the name of *Aulastomum lacustris*, in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1868, p. 229. The same leech, I think, I also saw in Lake Superior.

Mr. Carrington informed me that the head of a horse thrown into the lake from which he obtained the leeches, in a few hours appeared black from the number of them which adhered to it.

Thomas Say described two species of leeches obtained during Long's expedition, from small lakes on the high land between Lake Superior and Rainy Lake. These leeches, named *Hirudo marmorata* and *H. lateralis*, in neither case agree in character with the *Aulastomum lacustris.*

Several large hair-worms obtained from Fish Creek, Montana, are of the same species as that described from specimens obtained in Kansas by Dr. W. A. Hammond, upward of twenty years ago. These pertain to the largest known *Gordius.* The female is pale-brown; the male is dark-brown and has a strongly forked tail. The females of the Kansas specimens ranged from 10 inches to $2\frac{1}{2}$ feet in length; the males from 8 inches to upward of 2 feet. The females of the Montana specimens measure from $1\frac{1}{4}$ to $2\frac{1}{4}$ feet in length; and a male measures $8\frac{1}{2}$ inches in length. The species, under the name of *Gordius robustus*, is described in the Proceedings of the Academy of Natural Sciences of Philadelphia, for 1851, p. 275, and 1857, p. 204; and in the second volume of the American Entomologist, p. 194.

COLEOPTERA.

BY GEO. H. HORN, M. D., PHILADELPHIA.

In accordance with the request of the chief of the geological survey, Dr. Hayden, the following list of *Coleoptera* has been prepared. The specimens were collected for the most part by Mr. Cyrus Thomas and other members of the survey from June 1 to July 6 of the present year, over the following route: Starting from Ogden, Utah, through the Salt Lake Basin, by way of Brigham City, Box Elder Creek, Copenhagen, and Cache Valley; thence out of the Salt Lake Basin to Port Neuf River and Port Hall by way of Oxford and Marsh Valley; thence up the Snake River to near Henry's Fork; thence by Market Lake and Kamas Creek to the mountains between Idaho and Montana and to Virginia City, in the latter Territory. On reference to the map it will be seen that the route thus incloses an oblong space, intermediate between the faunal regions of Oregon and theplains to the eastward of the Rocky Mountains. As might be inferred from the

geographical position of the region, the species were a mixture of those from Oregon and those from the plains, the great mass being those more common in the latter region. A few years since a collection was made by Mr. Gabb, of the California geological survey, from Fort Klamath, Oregon, to Boise City, Idaho, completing with the present series a line from the Pacific to the plains. We are thus enabled to trace the distribution of various species and their varieties. As is well known to all collectors, various species of *Eleodes* occur in great numbers in all parts of the west of our continent, and the species themselves occur over a wide range of territory, and are not limited, as might be inferred from their apterous condition, to regions of small extent. As we pass from east to west over a given line, we find variations of average temperature, and of course great differences in altitude. These two causes, combined with, of course, the botanical changes, have tended to produce variations from a given type to a greater or less extent. *Eleodes obscura*, Say, affords a beautiful illustration of the extent to which this divergence may be carried. As a general rule I find, not only in *Eleodes*, but also in many other genera, that the higher the elevation or the colder the climate the rougher and more deeply sculptured is the species. The smoother forms of *E. obscura* may therefore be expected in the southern regions in which it occurs; for example, var. *dispersa* is New Mexican, elytra with scarcely any traces of striæ; var. *obscura*, elytra distinctly sulcate, but not deeply, is from Colorado and Southern Idaho. As we advance to the west the elytra are more deeply sulcate, as in var. *arata*, while var. *sulcipennis*, from nearer the Pacific coast, has deeply sulcate elytra, with very convex interspaces. The same variation of sculpture occurs in *Calosoma luxatum*, Say, which starts in Colorado with comparatively smooth elytra, until in Vancouver we find the elytra covered with lines of granular elevations, forming the variety known as *C. pimelioides*, Walker. The two extremes of each series above noted appear to differ widely from each other, and to be entitled to rank as distinct species. In the foregoing remarks reference only has been made to variations within specific limits. The same law appears to hold between different species. In the genus *Omus* the most roughly sculptured species occurs in Washington Territory, (*O. Dejeanii*, Reiche,) and the smoothest (*O. lævis*, Horn) from near Visalia, California. The object of the preceding remarks is to explain what appears to be a law of variation for our western slope, and thus cause the unnecessary multiplication of species, founded on slight characters, to be avoided.

Species everywhere in our fauna appear to be distributed on lines of country presenting as nearly as possible similar meteorologic conditions. Thus many Oregon forms extend southward into California, gradually seeking a higher mountain habitat as the region becomes warmer. Two species illustrate this—*Tragosoma Harrisii* and *Phryganophilus collaris*. Both extend their habitat from Maine to California, following the cooler regions westward from Maine through the Canadas and Red River region, thence northward nearly to Sitka. From the latter point southward to Oregon both occur at ordinary level, and rising as a more southern region is reached until at the latitude of Visalia they occur only a short distance below the snow-line, at an altitude of from ten to twelve thousand feet.

From Southern California species have extended along the desert regions bordering the Colorado River to Utah. Two instances are presented in the collection just examined—*Calosoma semilæve* and *Anisodactylus piceus*. Species advancing from the region just cited cannot be expected to cross the Rocky Mountains. Our common *Harpalus caligi-*

nosus extends westward over all obstacles until the base of the Sierra Nevada is reached. It has not yet occurred in California proper.

Owen's Valley, California, affords species of an Arizona origin as well as several sea-coast species from the San Diego region, comparatively few new or peculiar species occurring.

As might be expected each new region visited yields new *Meloidæ*, of the genera *Epicauta* and *Lytta;* in fact, each species of *Astragalus* has its peculiar *Lytta;* and wherever any of that genus of plants is found in flower, an accompanying vesicant may always be looked for.

One region of Arizona remains to be carefully explored, and good results may be expected in every branch of natural history. This is the elevated pine-growing region near Fort Whipple. The insects that have been collected indicate a temperate fertile region; and one, too, that is almost completely surrounded by desert and very hot valleys.

One gratifying fact may be noticed in the present collection. The progress of *Doryphora decemlineata* is not westward; and while eastern agriculturists view with great apprehension the steady and sure advance of that insect toward the Atlantic, none appear to have crossed the mountains to the west into the fertile valleys of the Salt Lake Basin. This enemy of the potato-plant is now, 1871, in Canada, north of Lake Erie, and from its known rate of travel farmers of the Atlantic slope may expect this new enemy in two or three years.

The following list contains the species collected by the various expeditions under Dr. Hayden, and although not very large is as much as can be expected when the great labor in other departments is considered:

After the name of each species, at the end of the line a letter is found indicating the name of the locality, as follows: K., Kansas and westward to Rocky Mountains; U., Utah; I., Idaho; M., Montana; C., California; O., Oregon; I. T., Indian Territory; N. M., New Mexico; N., Nevada. Where an asterisk (*) is placed after a name, it shows it to be very widely distributed.

CICINDELIDÆ.

Amblychila cylindriformis, Say	K.
Megacephala virginica, Dej	K.
Cicindela formosa, Say	K.
obsoleta, Say	K.
pulchra, Say	K.
Montana, Lec	I.
splendida, Htz	K. I.
repanda, Dej	U.
12-guttata, Dej	*
purpurea, Ol	*
Cicindela terricola, Say	K. C.
cuprascens, Lec	K.
macra, Lec	K.
fulgida, Say	K.
punctulata, Fab	*
circumpicta, Ferté	I. T.
celeripes, Lec	K.
cursitans, Lec	K.
decemnotata, Say	M.
vulgaris, Say	*
16-punctata, Klug	M.

CARABIDÆ.

Elaphrus ruscarius, Say	I.
californicus, Mann	K. C.
Carabus serratus, Say	K.
tædatus, Fab	I.
Calosoma semilæve, Lec	U.
haydenii, Horn	Col.
laqueatum, Lec	M.
zimmermanni, Lec	I. M.
calidum, Fab	K.
scrutator, Fab	K.
obsoletum, Say	K.
triste, Lec	K.
externum, Say	K.
Cychrus elevatus, Fab	K.
Omophron americanum, Dej	K.
nitidum, Lec	K.
Pasimachus validus, Lec	K.
elongatus, Lec	K.
obsoletus, Lec	K.
Scarites subterraneus, Fab	K.
Clivina bipustulata, Dej	K.
postica, Dej	K.
ferruginea, Lec	K.
Aspidoglossa subangulata, Lec	K.
Dyschirius sulcatus, Lec	K.
sphæricollis, Lec	K.
Brachinus cordicollis, Dej	U.
kansanus, Lec	K.

Brachinus cyanipennis, Say .... K.
Helluomorpha laticornis, Lap .... K.
Galerita atripes, Lec .... K.
Lachnophorus elegantulus, Mann .... C. K.
Casnonia pensylvanica, Dej .... K.
Lebia viridipennis, Dej .... K.
viridis, Say .... K.
pumila, Dej .... K.
bivittata, Fab .... K.
grandis, Htz .... K.
Blechrus linearis, Schaum .... K.
Axinopalpus biplagiatus, Lec .... K.
Glycia viridicollis, Lec .... N.
purpurea, Lec .... N.
Cymindis laticollis, Say .... K.
cribricollis, Dej .... K.
cribrata, Lec .... K.
pilosa, Say .... K.
reflexa, Lec .... M.
Calathus gregarius, Dej .... *
Platynus extensicollis, Lec .... *
deplanatus, Lec .... I.
punctiformis, Lec .... K.
nutans, Lec .... K.
chalceus, Lec .... K.
picipennis, Lec .... K.
Pterostichus caudicalis, Lec .... K.
mutus, Say .... K.
scitulus, Lec .... K.
cyaneus, Lec .... K.
chalcites, Say .... *
atratus, Lec .... U.
adstrictus, Esch .... I.
lucublandus, Kby .... K.
bicolor, Lec .... K.
Amara laticollis, Lec .... U.
furtiva, Say .... K.
augustata, Say .... K.
impuncticollis, Say .... M.
obesa, Say .... U.
interstitialis, Dej .... M.
terrestris, Lec .... K.
musculus, Say .... K.
Chlænius tomentosus, Dej .... K.
sericeus, Forst .... *
pensylvanicus, Say .... *
vafer, Lec .... K.
nebraskensis, Lec .... U.
Oodes amaroides, Dej .... K.
Dicælus lævigatus, Lec .... K.
splendidus, Say .... K.
sculptilis, Say .... K.
Diplochila laticollis, Lec .... K.
Nothopus zabroides, Lec .... I.
Geopinus incrassatus, Dej .... K.
Piosoma setosum, Lec .... K.
Cratacanthus dubius, Lec .... K.
Agonoderus lineola, Dej .... K.
pallipes, Dej .... K.
Harpalus caliginosus, Say .... *
amputatus, Say .... K.
rotundicollis, Kby .... K.
pensylvanicus, Lec .... *
compar, Lec .... *
stupidus, Lec .... K.
nitidulus, Chaud .... K.
ventralis, Lec .... K.
funestus, Lec .... K.
fraternus, Lec .... U.
lewisii, Lec .... U.
obesulus, Lec .... M.
Selenophorus pedicularius, Lec .... K.
æreus, Lec .... K.
ellipticus, Lec .... K.
Discoderus parallelus, Lec .... K.
tenebrosus, Lec .... K.
Spongopus verticalis, Lec .... K.
Xestonotus lugubris, Lec .... K.
Anisodactylus rusticus, Dej .... K.
pinguis, Lec .... K.
agricola, Dej .... K.
baltimorensis, Dej .... K.
coenus, Dej .... K.
piceus, Men .... U.
pitychrous, Lec .... I.
alternatus, Lec .... N.
Eurytrichus terminatus, Lec .... K.
Stenolophus ochropezus, Dej .... K.
dissimilis, Dej .... K.
Bradycellus badiipennis, Lec .... K.
rupestris, Lec .... K.
Bembidium punctatostriatum, Say .... K.
lævigatum, Say .... K.
nebraskense, Lec .... N.
coxendix, Say .... K.
americanum, Dej .... K.
dorsale, Say .... K.
patruele, Dej .... K.
pictum, Lec .... K.
quadrimaculatum, Gyll .... K.
affine, Say .... K.
nitidum, Lec .... K.
Tachys vivax, Lec .... K.
incurvus, Lec .... K.
dolosus, Lec .... K.
corruscus, Lec .... K.
inornatus, Lec .... K.
flavicauda, Lec .... K.

DYTISCIDÆ.

Haliplus fasciatus, Aube .... K.
immaculicollis, Harris .... K.
Hydroporus punctatus, Aube .... K.
lacustris, Say .... K.
semirufus, Lec .... K.
catascopium, Say .... *
patruelis, Lec .... K.
nubilis, Lec .... K.
discoideus, Lec .... K.
Laccophilus maculosus, Say .... K.
americanus, Aube .... K.
Coptotomus interrogatus, Say .... K.
longulus, Lec .... K.
Copelatus glyphicus, Say .... K.
Agabus clavatus, Lec .... K.
obliteratus, Lec .... K.
tæniolatus, Lec .... K.
And several undetermined species.
Colymbetes binotatus, Harris .... K.
seminiger, Lec .... U.
sculptilis, Kby .... K.
exaratus, Lec .... K.
Acilius ornaticollis, Aube .... K.
Eunectes sticticus, Er .... K.
Cybistes fimbriolatus, Say .... K.
explanatus, Lec .... U
Dytiscus marginicollis, Lec .... N.
harrisii, Kby .... K.

GYRINIDÆ.

Dineutus discolor, Aube	K.
Gyrinus picipes, Aube	I.
Gyrinus consobrinus, Lec	I.

HYDROPHILIDÆ.

Helophorus linearis, Lec	K.
lineatus, Say	K.
Laccobius agilis, Lec	K.
Hydræna pensylvanica, Kies	*
Berosus fraternus, Lec	K.
Hydrophilus triangularis, Say	*
lateralis, Fab	K.
Hydrophilus sublævis, Lec	K.
glaber, Hbst	*
Philhydrus nebulosus, Lec	K.
diffusus, Lec	K.
perplexus, Lec	K.
cinctus, Lec	K.
Hydrobius subcupreus, Lec	U.

SILPHIDÆ.

Necrophorus mediatus, Fab	K.
marginatus, Fab	K.
melsheimeri, Kby	K.
pustulatus, Hersch	K.
orbicollis, Say	K.
hecate, Bld	K.
Necrophorus velutinus, Fab	K.
Silpha lapponica, Hbst	*
truncata, Say	K.
peltata, Lec	*
ramosa, Say	K.
Agathidium exiguum, Mels	K.

PSELAPHIDÆ.

Tyrus humeralis, Aube	*
Bryaxis rubicunda, Aube	*

PHALACRIDÆ.

Phalacrus penicellatus, Say	K.
simplex, Lec	K.
Olibrus pallipes, Lec	K.

STAPHYLINIDÆ.

Falagria venustula, Er	K.
dissecta, Er	K.
Xantholinus obscurus, Er	K.
Staphylinus villosus, Grav	*
cinnamopterus, Grav	*
Philonthus hepaticus, Er.	
And several undetermined species.	
Acylophorus flavicollis, Sachse	K.
Sunius longiusculus, Er	K.
binotatus, Say	K.
Pæderus littorarius, Grav	K.
Pæderus compotens, Lec	N.
Lithocharis confluens, Er	K.
Euæsthetus americanus, Er	K.
Stenus egenus, Er.	K.
flavicornis, Er	K.
punctatus, Er	K.
Two undetermined species.	
Bledius pallipennis, Say	K.
Osorius latipes, Er	K.
Anthophagus brunneus, Say	K.
Glyptoma costale, Er	*

HISTERIDÆ.

Hololepta fossularis, Say	K.
lucida, Lec	K.
populnea, Lec	N.
Hister instratus, Lec	K.
biplagiatus, Lec	K.
gloveri, Horn	K.
Ulkei, Horn	K.
depurator, Say	K.
americanus, Payk	K.
subrotundus, Er	K.
carolinus, Payk	*
Hister lecontei, Lec	N.
parallelus, Say	N.
Saprinus lugens, Er	*
spurcus, Lec	K.
pratensis, Lec	K.
patruelis, Lec	K.
otiosus, Lec	I. T.
Plegaderus transversus, Lec	K.
nitidees, Hom	N.
fraternus, Hom	N.
Acritus exiguus, Lec	K.

NITIDULIDÆ.

Carpophilus caudalis, Lec	K.
apicalis, Lec	K.
carbonatus, Lec	K.
pallipennis, Lec	K.
Epurea rufa, Er	K.
Nitidula ziczac, Say	K.
uniguttata, Mels	K.
Omosita colon, Er	*
Phenolia grossa, Er	K.
Melegethes ruficornis, Lec	K.
sævus, Lec	K.
Pocadius helvolus, Er	K.
Pallodes silaceus, Er	K.
Ips sanguinolentus, Al	K.
quadrisignatus, Say	K.
cylindricus, Lec	N.

TROGOSITIDÆ.

Temnochila virescens, Er	K.
Trogosita castanea, Mels	K.
Trogosita corticalis, Mels	K.

CUCUJIDÆ.

Læmophlœus biguttatus, Mels	K.
Brontes dubius, Fab	K.
Silvanus planatus, Germ	K.
dentatus, Say	K.
Pediacus planus, Lec	N.
Catogenus rufus, Fab	K.
Cucujus puniceus, Mann	N.
clavipes, Fab	K.

COLYDIIDÆ.

Bothrideres geminatus, Er	K.
Cerylon castaneum, Say	K.

DERMESTIDÆ.

Dermestes marmoratus, Say	*
nubilus, Say	K.
caninus, Germ	K.
elongatus, Lec	K.
vulpinus, Fab	*
Dermestes mannerheimii, Lec	N.
Cryptorhopalum apicale, Munn	I.
Anthrenus lepidus, Lec	N.
Orphilus subnitidus, Lec	I.

PARNIDÆ.

Helichus striatus, Say	K.
Elmis glaber, Horn	Ar.

GEORYSSIDÆ.

Georyssus pusillus, Lec	K.
Georyssus, new species	Cal. N.

LUCANIDÆ.

Platycerus quercus, Sch	K.
Dorcus parallelus, Burm	K.
Lucanus dama, Humb	K.
lentus, Lap	K.

SCARABÆIDÆ.

Geotrupes opacus, Hald	K.
Odontæus filicornis, Say	K.
Bolbocerus farctus, Kl	K.
lazarus, Kl	K.
Canthon lævis, Mels	K.
chalcites, Mels	K.
vigilans, Lec	K.
ebenus, Mels	K.
nigricornis, Mels	K.
praticola, Lec	K.
viridis, Mels	K.
Onthophagus orpheus, Panz	K.
latebrosus, Fab	K.
Phanæus carnifex, McL	*
triangularis, Lec	K.
Copris anaglypticus, Say	K.
ammon, Fab	K.
Ochodæus musculus, Lec	K.
biarmatus, Lec	K.
Trox alternans, Lec	K.
tuberculatus, Ol	K.
sordidus, Lec	K.
capillaris, Say	K.
atrox, Lec	K.
scutellaris, Say	K.
pustulatus, Lec	K.
punctatus, Germ	K.
erinaceus, Lec	K.
morsus, Lec	K.
Aphodius denticulatus, Hald	K.
curtus, Hald	K.
granarius, Kby	K.
vittatus, Say	K.
femoralis, Say	K.
concavus, Say	K.
oblongus, Say	K.
occidentalis, Horn	I.
Atænius stereorator, Fab	*
Atænius gracilis, Say	*
Hoplia laticollis, Lec	K.
Macrodactylus augustatus, Lec	K.
Serica sericea, Burm	K.
vespertina, Dej	K.
robusta, Lec	N.
curvata, Lec	K.
Dichelonycha truncata, Lec	K.
Diazus rudis, Lec	K.
Diplotaxis obscura, Lec	K.
fondicola, Lec	K.
truncatula, Lec	K.
morula, Lec	K.
subangulata, Lec	N.
innoxia, Lec	K.
haydenii, Lec	K.
One new species.	
Listrochelus obtusus, Lec	K.
falsus, Lec	K.
fimbripes, Lec	K.
And one new species, female.	
Tostegoptera lanceolata, Bl	K.
Lachnosterna frontalis, Lec	K.
longitarsis, Lec	K.
futilis, Lec	K.
fusca, Lec	K.
fraterna, Lec	K.
rugosa, Lec	K.
affinis, Lec	K.
hirticula, Hope	K.
robusta, Lec	K.
crenulata, Lec	K.
glabricula, Lec	K.
tristis, Lec	K.
Polyphylla 10-lineata, Lec	K.
crinita, Lec	N.
hammondi, Lec	K.
Strigoderma arboricola, Burm.	

Anomala minuta, Burm .... K.
marginata, Burm .... K.
varians, Burm .... K.
Allorhina nitida, Lac .... *
Euryomia inda, Lac .... *
melancholica, Lac .... K.
sepulchralis, Lac .... K.
fulgida, Lac .... K.
areata, Lac .... K.
kernii, Lec .... K.
Cremastochilus nitens, Lec .... K.
knochii, Lec .... K.
saucius, Lec .... K.
schaumii, Lec .... N.
angularis, Lec .... I.
Osmoderma eremicola, Gory .... K.
socialis, Horn .... Ariz.
Ligyrus gibbosus, Lec .... K.
relictus, Lec .... K.
Aphonus pyriformis, Lec .... K.
tridentatus, Lec .... K.
Strategus mormon, Burm .... K.
Phileurus valgus, Dej .... K.
Xyloryctes satyrus, Burm .... K.
Cotalpa granicollis, Hald .... N.
ursina, Horn .... N.
puncticollis, Lec .... N.
consobrina, Horn .... Ariz.
Pelidnota punctata, Burm .... K.

BUPRESTIDÆ.

Ancylochira maculiventris, Lec .... K.
confluens, Lec .... K.
subornata, Lec .... K.
alternans, Lec .... K.
rusticorum, Kby .... I.
Chalcophora angulicollis, Lec .... I.
Melanophila longipes, Lec .... *
atropurpurea, Lec .... K.
miranda, Lec .... K.
fulvoguttata, Lec .... K.
Anthaxia quercata, Dej .... K.
viridicornis, Dej .... K.
Chrysobothris sexguttata, Lec .... K.
Dicerca prolongata, Lec .... K.
Pœcilonota cyanipes, Lec .... K.
Acmæodera mixta, Lec .... K.
4-vittata, Horn .... U.
Ptosima gibbicollis, Lec .... K.
Agrilus bilineatus, Say .... K.
latibrus, Lap .... K.
politus, Say .... K.
obolinus, Lec .... K.
lateralis, Say .... K.
Brachys terminans, Lap .... K.

ELATERIDÆ.

Tharops ruficornis, Lec .... K.
Hylocharis nigricornis, Lec .... K.
Microrhagus triangularis, Lec .... K.
Lacon rectangularis, Caud .... K.
Adelocera impressicollis, Lec .... K.
sparsa, Caud .... N.
marmorata, Germ .... K.
cavicollis, Lec .... I.
Alaus oculatus, Esch .... K.
myops, Esch .... K.
gorgops, Lec .... K.
naja, Lec .... N.
Cardiophorus erythropus, Er .... K.
tumidicollis, Lec .... I.
Œdostethus femoralis, Lec .... K.
Drasterius marginicollis, Horn .... N.
Monocrepidius auritus, Germ .... K.
bellus, Germ .... K.
vespertinus, Dej .... K.
Monocrepidius suturalis, Lec .... K.
Limonius auripilis, Lec .... K.
quercinus, Dej .... K.
basillaris, Lec .... K.
Melanotus variolatus, Lec .... I.
macer, Lec .... K.
incertus, Lec .... K.
clandestinus Er .... K.
fissilis, Lec .... K.
communis, Er .... *
cribulosus, Lec .... K.
Corymbites æripennis, Lec .... I.
fallax, Lec .... I.
glaucus, Lec .... N.
Athous cucullutus, Lec .... K.
ferrugineus, Esch .... I.
Asaphes hirtus, Cand .... K.
dilaticollis, Motsch .... K.
brevicollis, Cand .... K.

TELEPHORIDÆ.

Calopteron typicum, Lec .... K.
terminale, Lec .... K.
Photinus nigricans, Lec .... K.
corruscus, Lec .... K.
pyralis, Lap .... K.
Photuris pensylvanica, Lec .... K.
divisa, Lec .... K.
Chauliognathus marginatus, Htz .... K.
Chauliognathus basalis, Lec .... K.
profunda, Lec .... K.
Telephorus collaris, Lec .... K.
bilineatus, Lec .... K.
carolinus, Lec .... K.
Podabrus rugulosus, Lec .... K.
punctulatus, Lec .... K.
Trypherus latipennis, Lec .... K.

MALACHIIDÆ.

Collops bipunctatus, Er .... K.
tricolor, Er .... K.
punctatus, Lec .... K.
4-maculatus, Er .... K.
confluens, Lec .... K.
Collops punctulatus, Lec .... K.
One new species? .... U.
Dasytes senilis, Lec .... K.
Several undetermined species.

LYCTIDÆ.

Polycaon ovicollis, Lec	U.

CLERIDÆ.

Trichodes ornatus, Say	K.
nuttali, Kby	K.
Clerus analis, Say	K.
cordifer, Lec	K.
sphegeus, Fab	K.
Hydnocera humeralis, Nm	K.
subænea, Lec	K.
Enoplium pilosum, Lat	K.
quadripunctatum, Say	K.
damicorne, Spin	K.
Corynetes rufipes, Fab	*
violaceus, Fab	*
ruficollis, Fab	*

PTINIDÆ.

Ptinus fur, Linn	*
Sitodrepa panicea, Thoms	*
Dorcatoma simile, Say	K.
Niptus ventriculus, Lec	K.
Trypopitys punctatus, Lec	K.

TENEBRIONIDÆ.

Epitragus canaliculatus, Say	K.
pruinosus, Horn	N.
Edrotes rotundus, Lec	K.
ventricosus, Lec	N.
Trimytis pruinosa, Lec	K.
abnormis, Horn	N.
Emmenastus ater, Lec	I.
obesus, Lec	I.
Eurymetopon rufipes, Esch	N.
Asida opaca, Say	K.
polita, Say	K.
actuosa, Horn	N.
convexa, Lec	K.
semilævis, Horn	N.
consobrina, Horn	N.
luctata, Horn	N.
puncticollis, Lec	N.
sordidus, Lec	K.
elata, Lec	I.
Zopherus concolor, Lec	N. M.
elegans, Horn	N. M.
Hologlyptus anastomosis, Lac	K.
Eusattus reticulatus, Lec	K.
Coniontis ovalis, Lec	N.
Eleodes obscura, Lec	K.
acuta, Lec	K.
suturalis, Lec	K.
tricostata, Lec	K.
fusiformis, Lec	K.
extricata, Lec	K.
Eleodes carbonaria, Lec	K.
nigrina, Lec	K.
gracilis, Lec	K.
caudifera, Lec	K.
hispilabris, Horn	K.
armata, Lec	W.
opaca, Lec	K.
pimelioides, Mann	I.
Embaphion muricatum, Say	K.
contusum, Lec	K.
elongatum, Horn	N.
planum, Horn	K.
Cœlocnemis dilaticollis, Mann	U.
punctata, Lec	N.
Blapstinus interruptus, Lec	K.
metallicus, Fab	K.
pratensis, Lec	K.
vestitus, Lec	K.
pulverulentus, Mann	N.
Centronopus opacus, Lec	K.
Merinus lævis, Lec	K.
Nyctobates pensylvanicus, Lec	*
barbatus, Lec	*
Boletotherus cornutus, Fab	*
Paratenetus punctatus, Spin	*
Sitophagus pallidus, Lec	K.
planus, Lec	N.
Diaperis hydni, Fab	K.
Platydema excavatum, Lap	K.
Helops opacus, Lec	I.

CISTELIDÆ.

Allecula punctulata, Mels	K.
Allecula obscura, Say	K

MELANDRYIDÆ.

Eustrophus bicolor, Fab	K.
Melandrya labiata, Say	K.
Phryganophilus collaris, Lec	I.

ANTHICIDÆ.

Corphyra lewisii, Horn	K.
collaris, Say	K.
Stereopalpus guttatus, Lec	K.
Notoxus anchora, Htz	K.
serratus, Lec	K.
monodon, Ferte	K.
Notoxus marginatus, Lec	K.
subtilis, Lec	K.
Several undetermined species	K.
Anthicus elegans, Ferte	K.
rejectus, Lec	K.
cervinus, Ferte	K.

MORDELLIDÆ.

Mordella quadripunctata, Lec	K.
scutellaris, Fab	N.
insulata, Lec	K.
Mordella marginata, Mels	K.
Mordellistena æmula, Lec	K.
divisa, Lec	K.

MELOIDÆ.

Henous confertus, Lec	K.
Lytta reticulata, Say	K.
cooperi, Lec	N.
nuttali, Say	K.
vulnerata, Lec	N.
viridana, Lec	U.
cyanipennis, Lec	U.
sphæricollis, Say	K.
Pyrota engelmanni, Lec	K.
discoidea, Lec	K.
vittigera, Lec	K.
Epicauta pensylvanica, Lec	*
ferruginea, Say	K.
Epicauta maculata, Say	K.
corvina, Lec	I. T.
puncticollis, Mann	N.
Apterospasta segmentata, Say	K.
Macrobasis luteicornis, Lec	K.
longicollis, Lec	K.
fabricii, Lec	K.
Nemognatha lutea, Lec	U.
bicolor, Lec	K.
lurida, Lec	K.
piezata, Lec	K.
Gnathium minimum, Lec	K.
Zonitis atripennis, Lec	K.

ŒDEMERIDÆ.

Asclera puncticollis, Hald	K.
Oxacis sericea, Horn	N.
Nacerdes melanura, Fab	K.

CERAMBYCIDÆ.

Prionus palparis, Say	K.
imbricornis, Ol	K.
fissicornis, Hald	K.
emarginatus, Say	K.
californicus, Motsch	N.
Acanthoderes decipiens, Lec	K.
Liopus cinereus, Lec	K.
Leptostylus aculiferus, Lec	K.
Ædilis spectabilis, Lec	N.
Psenocerus pini, Ol	K.
Pogonocherus parvulus, Lec	K.
mixtus, Lec	K.
Saperda calcarata, Say	K.
mutica, Say	K.
discoidea, Fab	K.
puncticollis, Say	K.
Tetraopes femoratus, Lec	K.
annulatus, Lec	K.
oregonensis, Lec	N.
mancus, Lec	N.
Tetrops canescens, Lec	K.
Amphionycha ardens, Lec	K.
Stenostola pergrata, Lec	K.
saturnina, Lec	N.
Oberea perspicillata, Hald	K.
Monilema annulatum, Lec	K.
Leptura cribripennis, Lec	K.
rubrica, Say	K.
auripilis, Lec	K.
convexa, Lec	U.
Typocerus sinuatus, Lec	K.
Argaleus nitens, Lec	I.
Acmæops bivittata, Lec	K.
lupina, Lec	I.
Acmæops subpilosa, Lec	U.
dorsalis, Lec	K.
marginalis, Lec	I.
strigilata, Lec	K.
Monohammus scutellaris, Lec	*
Clytus scutellaris, Dej	K.
erythrocephalus, Fab	*
undulatus, Say	K.
capræa, Say	K.
Purpuricenus humeralis, Dej	K.
Tylosis maculatus, Lec	N.
Rhopalophorus longipes, Lec	K.
Arhopalus fulminans, Serv	K.
charus, Lec	K.
pictus, Lec	K.
eurystethus, Lec	N.
Eriphus ignicollis, Lec	K.
discoideus, Say	K.
Sphenothecus suturalis, Lec	U.
Elaphidion villosum, Hald	K.
parallelum, Nm	U.
debile, Lec	K.
mucronatum, N	K.
Eburia quadrigeminata, Hald	K.
Heliomanes bimaculatus, Nm	K.
Dryobius sexfasciatus, Lec	K.
Callidium variabile, Fab	K.
amœnum, Say	K.
brevilineum, Say	K.
Asemum mœstum, Mann	I.
atrum, Fab	K.
Criocephalus productus, Lec	K.
asperatus, Lec	K.
agrestis, Hald	*

CHRYSOMELIDÆ.

Anomoia laticlavis, Forst	K.
Babia quadriguttata, Lac	K.
Coscinoptera axillaris, Lec	K.
franciscana, Lec	K.
Cryptocephalus lativittis, Germ	K.
guttulatus, Al	K.
Cryptocephalus mucoreus, Lec	K.
notatus, Ol	K.
quadriguttulus, Suff	K.
dispersus, Hald	K.
venustus, Fab	K.
fasciatus, Say	K.

Cryptocephalus amatus, Hald .... K.
viridis, Hald .... K.
vitticollis, Lec .... K.
confluens, Say .... K.
Pachybrachys hepaticus, Hald .... K.
tridens, Mels .... K.
mollis, Hald .... K.
viduatus, Suff .... K.
And several of both preceding genera undetermined.
Colaspis favosa, Say .... K.
Several unnamed.
Metachroma interruptum, Lec .... K.
pallidum, Lec .... K.
Paria sexnotata, Lec .... K.
aterrima, Lec .... K.
opacicollis, Lec .... K.
Myochrous denticollis, Lec .... K.
squamosus, Lec .... K.
Chrysomela scalaris, Lec .... K.
philadelphica, Linn .... K.
multipunctata, Say .... K.
exclamationis, Fab .... K.
conjuncta, Rog .... K.
disrupta, Rog .... K.
lunata, Fab .... K.
pulchra, Fab .... K.
incisa, Rog .... K.
auripennis, Say .... K.
flavomarginata, Say .... K.
interrupta, Fab .... K.
Chrysomela dissimilis, Fab .... K.
formosa, Fab .... K.
adonidis, Linn .... Mon.
Doryphora 10-lineata, Say .... K.
rogersii, Lec .... K.
trimaculata, Say .... K.
Blepharida rhois, Rog .... K.
Œdionychis gibbitarsa, Lec .... K.
scripticollis, Lec .... K.
Several undetermined .... K.
Disonycha, several undetermined.
Glyptina spuria, Lec .... K.
Longitarsus nigripalpus, Lec .... K.
rubidus, Lec .... K.
Chætochema subviridis, Lec .... K.
denticulata, Lec .... K.
Cerotoma caminea, Fab .... K.
Diabrotica longicornis, Say .... K.
vittata, Fab .... *
tricincta, Lec .... K.
Galeruca americana, Fab .... K.
externa, Say .... K.
Stenispa collaris, Baly .... I. T.
Anoplitis scapularis, Lec .... K.
rosea, Lec .... K.
Microrhopala lætula, Lec .... K.
cyanea, Lec .... K.
Chelymorpha cribraria, Ol .... K.
Cassida nigripes, Ol .... K.
pallida, Hbst .... K.
guttata, Ol .... K.

BRUCHIDÆ.

Bruchus discoideus, Say .... K.
Spermophagus robiniæ, Sch .... K.
And several others of the family yet unstudied.

COCCINELLIDÆ.

Anisosticta vittigera, Lec .... K.
episcopalis, Lec .... K.
Hippodamia glacialis, Mels .... *
13-punctata, Mels .... *
lecontei, Muls .... K.
convergens, Guer .... *
parenthesis, Lec .... *
And one new species. ?
Coccinella transverso—guttata, Fald .... K.
monticola, Muls .... K.
novemnotata, Hbst .... *
abdominalis, Say .... K.
Brachyacantha albifrons, Lec .... K.
tau, Lec .... K.
10-pustulata, Lec .... K.
Hyperaspis vittigera, Lec .... K.
quadrivittata, Lec .... K.
elegans, Muls .... K.
pratensis, Lec .... K.
Œneis pusilla, Lec .... K.
Scymnus collaris, Muls .... K.
caudalis, Lec .... K.
And several undetermined.

RHYNCHOPHORA.

Under this head are included the several families of snout-bearing beetles, all more or less injurious to vegetation and represented in all parts of our country by numerous species. These have been as yet but little studied and very few are named. As a systematic list of genera and species is in progress, only those now known will be mentioned.

ANTHRIBIDÆ.

Cratoparis lunatus, Sch .... K.

ATTELABIDÆ.

Attelabus nigripes, Lec .... K.
Pterocolus ovatus, Sch .... K.
Rhynchites bicolor, Hbst .... K.
Rhynchites æneus, Boh .... K.
æratus, Say .... K.
Apion, several species.

CURCULIONIDÆ.

Ophryastes latirostris, Lec .... K.	Thecesternus humeralis, Say .... K.
ligatus, Lec .... K.	rectus, Lec .... K.
sulcirostris, Sch .... K.	rudis, Lec .... K.
vittatus, Sch .... K.	erosus, Lec .... K.
tuberosus, Lec .... I.	morbillosus, Lec .... K.
Epicærus imbricatus, Say .... K.	Piazorhinus scutellaris, Sch .... K.
Platyomus auriceps, Sch .... K.	Rhysematus lineaticollis, Say .... K.
Tanymecus canescens, Sch .... K.	Conotrachelus posticatus, Sch .... K.
conferteus, Sch .... K.	Sphenophorus pulchellus, Sch .... K.
Cleonus pulvereus, Lec .... K.	cultirostris, Germ .... K.
trivittatus, Say .... K.	compressirostris, Say .... K.
angularis, Lec .... K.	13-punctatus, Say .... U.
Lepyrus geminatus, Lec .... K.	Cossonus subareatus, Sch .... K.

SCOLYTIDÆ.

Tomicus pini, Harris .... K.	Dendroctonus terebrans, Ol .... K
caligraphus, Germ .... K.	

NOTICES OF THE HEMIPTERA OF THE WESTERN TERRITORIES OF THE UNITED STATES, CHIEFLY FROM THE SURVEYS OF DR. F. V. HAYDEN.

By P. R. Uhler.

In order to give a more complete representation of the hemipterous fauna of the regions explored by Dr. Hayden, certain species have been introduced which were collected by other persons at different times.

To do full justice to the vast territory embraced in the surveys would demand close attention to collecting during several years. As this has not yet been possible, we can only include the scanty materials which have been brought together by the industry of a very few individuals.

A country presenting such diversity of surface, and climate so varied, must offer great variations in the species which belong to it; and, in fact, such proves to be the case; as, for instance, may be seen in *Chelinidea*, *Lygus*, and some *Cicadæ*. The former genus varies in the color of the antennæ, and still more in their width; in some specimens the joints of these organs are flattened into almost lamellate expansions. A *Lygus*, which, in many respects, resembles the European *L. pratensis*, Fab., varies in form, size, and pattern of marking. Melanism seems to prevail in the species belonging to the mountains of Nevada; while in Colorado and Idaho they present the richest and brightest colors.

HEMIPTERA.

HETEROPTERA.

Family Corimelænidæ.

Corimelæna, White.

1. *C. nitiduloides*, Wolff, (Icones Cim., p. 98, Tab. 10, fig. 92.)—The western specimens generally differ from the eastern in lacking the depres-

sion on each side of the pronotum. Occasionally, however, a specimen occurs with faint traces of these depressions. Some variation in the width and acuteness of the corium occurs in specimens from both sides of the continent.

2. *C. extensa*, Uhler, (Proc. Entomol. Soc. Phila., 1863, p. 155.)—This species bears some resemblance to *C. marginipennis*, Spinola, of Chili; but it may be at once distinguished from it by the narrower, longer, and more convex head. Our species is found in Dakota, Arizona, Oregon, and California.

Family PACHYCORIDÆ.

Homœmus, Dallas.

1. *H. aeneifrons*, Say, (Long's Expedition, vol. II, Appendix, p. 299;) *Pachycons exilis*, H. Schf., (Wanz. Ins., vol. IV., Tab. 110, Fig. 346.)—It was obtained in Colorado, but has been found as far east as Maryland and in New England.

2. *H. bijugis.* New species.—Elongate-oval, pale testaceous. Head long, somewhat triangularly narrowing to the tip, the lateral lobes a little rounded, the surface black, brassy, rather finely punctured, clothed with remote, pale pubescence, the lateral margin and a submarginal line yellow; tylus a little longer than the lateral lobes; ochro-testaceous, as is also the basal joint of the antennæ; the bucculæ, adjoining margin, and base of the inferior cheeks, yellow; rostrum testaceous, reaching to the middle of the second ventral segment, the apex piceous. Pronotum regularly convex, the lateral margin straight, oblique, the edge smooth, broadly compressed; the middle of the submargin deeply indented; the surface remotely, finely, obsoletely punctured with pale fuscous; each side of middle is a pale fuscous, slightly oblique ray; exterior to this a fainter ray, and sometimes another adjoining it, or running from the humerus; callosities occupied by a more or less deep black spot; the intra-humeral line deeply impressed, forming a sinus on the postero-lateral margin; the posterior angles moderately rounded; anterior angles feebly rounded, covering the whole width of the base of the eyes. Pectus pale croceous, with uncolored, coarse punctures, with a black spot in the antero-exterior corner. Legs testaceous, punctured on the thighs, having at most but three or four fuscous dots at tip; spines of tibiæ black; tarsi piceous at tip, the nails tipped with black. Scutellum rather long, ovately narrowing to the tip, punctured with brown, faintly clouded at base, and with a darker cloud behind the middle; the middle line almost white, expanded at tip, and bounded there by a blackish line; each side of base a blackish ray curves obliquely outward to beyond the middle. Venter yellowish-white, minutely punctured, with a few large fuscous punctures at base and about the disk; connexivum immaculate and narrowly grooved beneath, the edge sharp; the superior connexivum black interiorly, exteriorly pale yellowish, faintly punctured. The male is much smaller, with the scutellum a little more acute at tip, more or less reticulated with black over the entire upper surface, and with at least four longitudinal, faint, fuscous rays on the pronotum, and two oblique ones each side of scutellum. The middle line and its apical dilation faintly indicated. The yellow line of the head is slender, waved, obsolete toward the base, the tylus marked with yellow before the tip.

Length, ♀, 8; ♂, 6, millimeters. Width at base of pronotum, ♀, $4\frac{1}{2}$; ♂ 4, millimeters.

Specimens have been received from Colorado and Nebraska.

Subfamily HALYDIDÆ.

Brochymena, Amyot et Serv.

1. *B. serrata*, Fab., (Syst. Rhyng., p. 181, No. 2;) *Halys pupillata*, H. Schf., (Wanz. Ins., IV, Pl. 144, Fig. 453.)—Obtained in Colorado; but quite common as far east as Pennsylvania. Quite variable in the length of the second and third joints of the antennæ. Usually these two joints are about equal in length, but sometimes the second is very little more than one-half the length of the third; specimens have occurred to me in which these joints have been equal in the one antenna, and the second shortest in the other antenna.

2. *B. arborea*, Say, (Proc. Acad. Phila., IV, p. 311;) *Halys erosa*, H. Schf., (Wanz. Ins., V, Pl. 166, Fig. 515.)—Indian Territory, Texas, Mexico, and in all the Atlantic States from Maine to Florida. The southern specimens are generally more brightly colored.

Prionosoma, Uhler.

P. podopoides, Uhler, (Proc. Entom. Soc. Phila., 1863, p. 364.)—This species varies considerably in depth of color, and somewhat in the distinctness of the armature of the thorax and abdomen. It is common in California and extends into Arizona.

Subfamily CYDNIDÆ.

Microporus, Uhler.

M. obliquus. New species.—Chestnut-brown, polished; the lateral margins of thorax and corium densely fringed with coarse, long, yellowish hairs. Face almost flat, each side with long, oblique, punctured striæ; the tylus transversely, feebly striated; anterior margin bluntly rounded, thickly beset with short, erect teeth, and interspersed with a few long hairs; the lateral lobes sparingly punctured, with a round fovea adjacent to each eye, and another near the tip, each side of the tylus. Rostrum bright testaceous, extending to the intermediate coxæ; the apical joint slender, a little shorter than the third. Antennæ, first two joints slender, the remaining three moniliform, the second shortest; apical joint a very little the longest, the third and fourth subequal. Base of the head convex, impunctured. Pronotum, lateral margins a little oblique, densely ciliate, the anterior angles a little advanced, rounded; the anterior half of surface impunctured, excepting only along the anterior margin and sides; posterior half remotely, rather coarsely punctured, with a few transverse, obsolete wrinkles behind the middle; the posterior margin impunctured; middle transverse line distinct, having several coarse punctures each side of its ends; humeral angles prominent, the margin inwardly from them sinuated. Anterior tibiæ armed on the front margin with long and very stout spines; tarsi pale yellow. Scutellum polished, rather remotely punctured, the base almost destitute of punctures; tip a little depressed, bluntly, angularly rounded. Hemelytra remotely punctured, the apical punctures becoming finer and almost obsolete, the lateral margin expandedly arcuated, at base ciliated with long hairs; membrane and wings milk-white. Venter smooth on the middle, the sides minutely scabrous; anal segment punctured; the lateral margins ciliated with slender hairs.

Length, $4\frac{1}{2}$ millimeters; width at base of thorax, $2\frac{1}{3}$ millimeters.

A male was brought from Ogden, Utah, by the survey of 1870.

Subfamily PENTATOMIDÆ.

Perillus, Stål.

1. *P. claudus*, Say, (Jour. Acad. Phila., vol. IV, p. 312, No. 2.)—Inhabits Colorado, California, Kansas, &c. The present specimen, of the pale variety, is from Ross Fork, Idaho.

2. *P. exapta*, Say, (Jour. Acad. Phila., vol. IV, p. 313, No. 3.)—Colorado. It varies in the width of the black upon the pronotum, and this color is indeed sometimes entirely absent from that part. Specimens have passed through my hands which had been collected in British America, New England, Illinois, and in several of the regions west of the Mississippi River.

3. *P. circumcinctus*, Stål., (Entomol. Zeitung, Stettin, vol. 23, p. 89, note.)—Dakota. Scarcely a species found in our Territory extends over so wide a surface as this. It is found on the Isthmus of Panama, in the island of Trinidad, and in Canada, New England, and New York.

Podisus, Stål.

P. spinosus, Dallas, (British Museum List. Hemipt., p. 98, No. 7.)—A common insect in most parts of the Atlantic region, and extending as far west as Nebraska and south into Texas. Two specimens from Fort Cobb, Indian Territory, seem to offer no differences from those common in Maryland and Pennsylvania.

Zicrona, Amyot et Serv.

Z. cuprea, Dallas, (British Museum List, p. 108, No. 2.)—After diligently comparing specimens from both continents, no sufficient differences have prevailed to separate this from the *Z. cœrulea*, Linn. Small variations in the color and in the distinctness of the punctures are apparent in specimens from both localities; but in a series of specimens these are seen to be gradations between the opposite extremes. The present specimens are from Snake River, Idaho, and from Fort Defiance, New Mexico. Mr. Dallas's type came from the vicinity of Hudson's Bay.

Cosmopepla, Stål.

C. carnifex, Fab., (Ent. Syst., Suppl., 535, No. 162.)—Inhabits Nebraska, Indian Territory, Texas, and the Eastern United States and Canada. It exhibits much variation in the depth and amount of red on the pronotum and abdomen.

Neottiglossa, Kirby.

N. undata, Say, (Heteropt., New Harmony, p. 8, No. 17;) *N. trilineata*, Kirby, (Fauna Bor. Amer., p. 276.)—This species occurs in Nebraska, Canada, and throughout most of the northern parts of the United States.

Mormidea, Amyot et Serv.

M. lugens, Fab., (Ent. Syst., IV, p. 125;) *Pentatoma punctipes*, Say, (Jour. Acad. Phila. IV, p. 313.)—From Cheyenne, and Indian Territory. It extends as far south as Matamoras, Mexico, and inhabits almost the whole region east of the Mississippi River.

Murgantia, Stål.

M. histrionica, Hahn, (Wanz. Ins., vol. II, pl. 65, Fig. 196.)—Collected in Colorado; but injures cabbages and other garden vegetables in the Southern States, from Maryland to Texas, and even into Mexico. Several of the links in the chain of varieties between this species and *M. munda*, Stål., have already been found, and we may expect hereafter to see the two species united as mere forms of one.

Cœnus, Dallas.

1. *C. delia*, Say, (Heteropt., New Harmony, p. 8, No. 18;) *C. tarsalis*, Dallas, (British Museum, List. Hemipt., p. 230, Pl. 8; Fig. 6.)—From Fort Cobb, Indian Territory, also in most of the Eastern States.
2. *C. æqualis*, Say, (Heteropt., New Harmony, p. 7, No. 15.)—Same localities as the preceding.

Euschistus, Dallas.

1. *E. fissilis*. New species.—Differs from *E. serva*, Say, its near congener, in the cleft head and prolonged lateral lobes of the head. It is larger than *E. punctipes*, Say, and the humeral angles are much less acute. It is found in Colorado, Nebraska, and Illinois.
2. *E. punctipes*, Say, (Jour. Acad. Phila., IV, p. 314, No. 5.)—Colorado, and most parts of the Eastern United States.
3. *E. pyrrhocerus*, H. Schf., (Wanz. Ins., vol. VI, Fig. 638.)—From Fort Cobb, Indian Territory, but not uncommon in Missouri and in the Atlantic region. It varies in the acuteness of the humeral angles.

Peribalus, Stål.

P. modestus. New species.—Grayish-yellow, general form of *P. vernalis*, Wolff; but with the humeral angles less prominent, and the lateral margins of the pronotum not sinuated. Upper surface of the head finely punctured with black, the punctures more dense and forming a submarginal spot or short streak before each eye; the intra-orbital surface with a smooth, impunctured, short line; the lateral margins a little reflexed, slightly sinuated a little in advance of the eyes; the side lobes much longer than the tylus, usually meeting before it, but not always quite in contact at the tip. Under side of head pale yellowish, irregularly punctured, the angle before the eye more or less black, the lateral edge piceous or black. Antennæ rufous or testaceous; the basal joint pale yellowish, shorter than the head; the fourth joint, excepting base and tip, and the fifth, excepting the base, blackish; the last stout, longest; the former quite stout, not quite so long as the latter, but longer than the others; second and third slender, subequal. Rostrum pale testaceous, the middle line and all but the base of the apical joint blackish-piceous, extending to the intermediate coxæ; the second joint much the longest; apical joint much the shortest; the third joint a little longer than the fourth. Pronotum rather short and broad, a little more coarsely and less densely punctured than the head; the punctures dense, making a blackish stripe along the lateral submargin; the lateral margins straight, thickened, elevated, yellowish or white, smooth, impunctured; latero-posterior margins feebly sinuated; humeri rounded, very slightly prominent. Pectus pale testaceous, unevenly punctured; the areas of the pleural pieces with punctures more or less brownish, usually with a

black dot near the middle of each of the three principal segments. Legs pale testaceous; the femora with numerous black points, a few of them at the tip larger; the tibiæ with minute brown punctures; tarsi pale rufous; the nails black, excepting the base. Scutellum a little rugulose, somewhat confluently punctured, more finely so than the pronotum, and near the tip still more finely and densely so; the apex smooth, broadly white. Corium finely, less densely, punctured than the pronotum; the exterior suture often with a streak of closer punctures; the general surface sometimes appearing reticulatedly punctured; the costal margin and embolium whitish, the latter with a few punctures; membrane slightly embrowned, having six or seven dark, longitudinal nervures. Tergum black, minutely, densely rugulose and punctured; the apical segment margined with yellow; connexivum black, coarsely and partly confluently punctured, the outer margin yellow, with the inner edge of that color scalloped. Venter pale testaceous, or in life greenish-white, very sparingly punctured on the smooth disk; the sides finely rugulose, and thickly punctured; the general puncturing often red, the large punctures black, and arranged in a triple series of wavy, faint spots each side, and with a geminate group at the outer angles of the incisures; the apical angles of the sixth segment a little rounded and carrying a black dot.

In the males the finer punctures of the venter are usually red and more evenly distributed; the coarser ones are black and not arranged in spots; the genital segment is deeply emarginated, and each side of it sinuated.

Length of ♂, 8½; of ♀, 8–9½ millimeters. Width across the humeri, 5–6 millimeters.

Arizona, Kansas, Colorado, New England, and generally throughout the States east of the Mississippi.

Holcostethus, Fieb.

H. abbreviatus. New species.—Fusco-cinereous more or less spotted with black, rugulose, and finely punctured with black. Head broad and long, convex along the base of the tylus, broadly rounded in front, closely, confluently punctured, more densely so along the sides and in front; the lateral lobes flat, with sharp edges, a little expanded in front of the eyes; the lobes meeting in front of the tylus, but scarcely in contact on the extreme tip; under side of the head pale yellowish, coarsely punctured, with the margin and a few coarse punctures in front of the eye deep black. Rostrum extending to the venter, yellow, with the tip black. Antennæ long and slender, reddish-yellow, or rufous; the basal joint pale, very short; second and third subequal, shorter than the following; fourth and fifth much longer, subequal. Pronotum broad and short; the lateral margins smooth, yellow, a little arcuated; the humeri somewhat prominent, rather broadly rounded; the submargins made almost black by the dense punctures; surface somewhat broken, irregularly spotted with piceous and black, the transverse impressed line distinct; pectoral segments coarsely and irregularly punctured with brownish, each with from one to three black dots, including one on the osteole. Scutellum a little indented before the middle, finely and closely punctured with black, still more so in spots at base, where are also two or three small white spots or streaks; the apex bluntly rounded, white. Legs testaceous, minutely and sparsely punctured with brown; the femora a little scabrous; tibiæ at tip and tarsi rufescent; the nails black at tip. Tergum black, the connexivum yellow, with double black spots

at the ends of the incisures; venter yellowish, the punctures closer on the sides, and with about three series of obsolete patches of blackish punctures each side; the lateral edge smooth, orange, with a small, double black spot at the incisures; sometimes with the margin of the anal segment black.

Length, 8½ to 10 millimeters; width across the humeri, 5 to 6 millimeters.

It inhabits Kansas, Colorado, and California. The general appearance is somewhat that of *H. sphacelatus*, Fab., of Europe; but it may be known from it at a glance by the lateral margins of the pronotum, which are not sinuated, but bowed. The lateral lobes fail to meet anteriorly in one specimen, making the front of the head appear cleft.

Carpocoris, Kolenati.

C. lynx, Fab., (Syst. Rhyng., p. 168, No. 68.)—From Southern Montana, but attains to colossal proportions in California. After close comparison of a series of specimens of very various sizes and colors, with several individuals from Europe, and with the figures and descriptions in the several authorities, I fail to find permanent characters to separate them. Specimens vary in colors from pale green or yellowish to rosy red; either have or do not have black spots on the connexivum, and the size ranges from 8 to 11 millimeters in length, with corresponding width.

Pentatoma, Latr., (Fieber.)

1. *P. granulosa.* New species.—General appearance of *P. juniperi*, Linn. Bright grass-green, or pale sap-green, paler beneath, deeply, confluently, rather finely punctured, transversely, minutely wrinkled on the head, pronotum, and scutellum; the surface of the latter, the hemelytra, and sometimes the pronotum, with numerous sphacelated, smooth, whitish points; the lateral margins of pronotum, the costal margin of corium to beyond the middle, and the apex of the scutellum white, rarely yellow. Rugulæ of the entire under surface whitish. Head narrowed toward the tip; the tip of the lateral lobes almost acute, a little recurved, slightly longer than the tylus; the occiput bald, almost impunctured. Antennæ black, stout; the tooth at base long and slender; basal joint green, very stout, hardly more than one-half as long as the second; the second longest; third a little more than two-thirds as long as the second; fourth and fifth subequal, somewhat longer than the third. Rostrum pale green, reaching between the posterior coxæ; the apical half of the end joint black or piceous; the labrum sometimes blackish. Lateral margin of pronotum a little sinuated, the edge distinctly elevated, the sub-margin depressed, and the surface broadly impressed at the outer end of the callosities. Callosities defined by sinuated, grooved, smooth lines, which are bifurcated at the outer extremity. Embolium whitish, having two or three irregular series of obsolete, small punctures; membrane white or only very faintly brownish. Femora obsoletely wrinkled, the tips of tarsal joints infuscated, and the tips of nails piceous. Tergum black, excepting the penultimate and anal segments; the connexivum green. Base of scutellum sometimes with small, white spots.

Length, 11–13 millimeters; width across the humeri, 6–8 millimeters.

The specimens from this survey were found in Montana, and near Ogden, Utah. It seems to be widely spread in the Western Territories, and extends as far as California. Two specimens exhibit the third and fourth joints of the antennæ green at base, the former very broadly so.

In three other specimens the basal and second joints are entirely green. The third joint varies in length, being from one-half to two-thirds the length of the second.

2. *P. ligata*, Say, (Heteropt., New Harmony, p. 5, No. 6;) *Cimex rufocinctus*, H. Schf., (Wanz. Ins., IV, p. 94, Fig. 436.)—This species inhabits Arizona, Missouri, Texas, and California.

3. *P. faceta*, Say, (Jour. Acad. Phila., IV, p. 315, No. 6.)—Apparently a rare species, of which single specimens have been obtained in Colorado, Dakota, and California.

Thyanta, Stål.

1. *T. perditor*, Fab., (Entom. Syst., IV, p. 102, No. 90;) *Pentatoma fascifera*, Beauv., (Ins. Afr. et Amer., p. 150; Pl. X, Fig. 8.)—The most typical form of this species inhabits the West Indies and Mexico; those with the humeral angles shortest are found in Nebraska. It seems to be a very common species in the regions adjacent to the Rocky Mountains.

2. *T. custator*, Fab., (Syst. Rhyng., p. 164, No. 43;) *Pentatoma calceata*, Say, (Heteropt., New Harmony, p. 8, No. 19.)—This exceedingly variable species inhabits almost the whole of North America. The most brilliant green specimens are usually to be met with in the Southern States. The variety *calceata* is common in Maryland, and specimens without the transverse stripe are common as far south as Cape Saint Lucas, California.

3. *T. rugulosa*, Say, (Heteropt., New Harmony, p. 7, No. 16.)—This seems to be a rare species. A single specimen has occurred to me, found in Colorado, and another, collected in Cuba. This shows a wide geographical range, and no doubt the intervening regions will yet furnish specimens of it.

Family COREIDÆ.

Archimerus, Burm.

A. calcarator, Fab., (Syst. Rhyng., p. 192, No. 3;) *Coreus alternatus*, Say, (Jour. Acad. Phila., IV, p. 317, 1;) *Piezogaster albonotatus*, Amyot, (Hemiptères, p. 197.)—A species widely distributed throughout the United States. The present representative is from Colorado.

Metapodius, Westw.

1. *M. Thomasii*. New species.—Reddish or cinnamon-brown, minutely shagreened. General form of *M. terminalis*, Dallas. Head black, polished, remotely pubescent, with a narrow fulvous line on the middle and another each side, adjacent to the eye; cranium transversely impressed behind the ocelli; the tylus more or less rufous above. Rostrum blackish, extending to the intermediate coxæ. Antennæ fuscous or black, minutely granulated, closely, minutely setose; the apical joint orange; the basal a little shorter than the apical one; the second much shorter than the basal, but a little longer than the third. Pronotum sparsely clothed with minute, pale pubescence, minutely, roughly punctured, beset with granular minute protuberances, which are very remote on the middle, but thickly crowded near the sides; lateral margins with a few short teeth, which are erect anteriorly and oblique posteriorly; the humeral angles moderately prominent, angu-

lar; the latero-posterior margins abruptly sinuated. Propleura roughly punctured, having only a very few tubercles; meso- and metapleura more or less obsoletely, and postero-interiorly, coarsely punctured. Legs black; anterior and intermediate tibiæ and all the tarsi reddish-orange or fulvous, the nails piceous; posterior femora stout, in the male much stouter, compressed, shagreened, the outer margin forming a broad ridge, which bears a series of tubercles, and parallel to this, inwardly, runs a broad groove; the middle surface closely beset with large tubercles. On the middle below is a large spur, at the tip two stout teeth, and along the margin five or six smaller ones. The under surface is likewise grooved, and somewhat tuberculated; posterior tibiæ foliated exteriorly throughout the whole length, densely scabrous; the outer margin gradually arcuated at base, abruptly rounded at tip, with two teeth near the tip and one at its inner corner; the inner margin not expanded, granulated, armed with several teeth near the tip; the tip ferruginous ♂. Posterior femora of female more arcuated, fusiform, feebly grooved both above and below, scabrous, pubescent, granulated, with small teeth on the upper outer margin, and four or more large oblique spurs on the inner margin, from beyond the middle to the tip; tibiæ broadly foliated, roughened, and minutely granulated; the outer division sinuated behind the middle and carried back considerably beyond the tip of the shank; the inner division much narrower, very much narrowed from behind the posterior two-thirds to the tip; the margin ridged and coarsely granulated. Odoriferous glands, orange. Scutellum and hemelytra minutely shagreened, the membrane black, or bronzed black-brown. Tergum fuscous, with a yellow stripe from behind the middle to near the tip. Venter paler fuscous, minutely roughened, and coated with fine pubescence; the hemelytra a little longer than the abdomen.

Length, to tip of venter, 28–29 millimeters; width across the humeri, 9½–10 millimeters.

A male and female from Arizona were the only specimens obtained. The species is named in recognition of the services of Professor Cyrus Thomas, who has labored so successfully in bringing together the species of western *Hemiptera*.

2. *M. terminalis*, Dallas, (British Museum List, II, p. 431, No. 10.)—Brought from near Fort Cobb by Dr. E. Palmer. It is a very variable species in size, in the amount of tuberculation of the pronotum, and in the width of the foliaceous processes of the posterior tibiæ. It inhabits most of the Southern States, and seems to be quite common in Texas.

Merocoris, Perty.

M. distinctus, Dallas, (British Museum List, II, p. 419, No. 2.)—This is also a common species in many parts of the Union, from Northern New York to Florida. One specimen of the usual form was collected in Colorado.

Leptoglossus, Guer.

L. phyllopus, Linn., (Syst. Nat., ed. 12, p. 731;) *Anisoscelis albicinctus*, Say, (Heteropt., New Harmony, p. 12, No. 2.)—Several specimens were collected near Fort Cobb, Indian Territory, by Dr. E. Palmer. The species is common in the States south of the Ohio River, and it extends into Central Texas.

Chelinidea, Uhler.

C. vittigera, Uhler, (Proc. Entom. Soc. Phila., II, p. 366.)—Brought by the survey from Ross Fork, Idaho; Ogden, Utah; and by Dr. E. Palmer from New Mexico. In Texas it infests a species of *Opuntia*, sometimes in considerable numbers. A few specimens have been taken near the Kanawha River, in Virginia. It varies in the color of the antennæ, from red to black, and in the width of the joints, which are sometimes very broadly compressed.

Margus, Dallas.

M. inconspicuus, H. Schf., (Wanz. Ins., VI, Fig. 570.)—Collected in Colorado. It has been also found in Texas, Mexico, and California.

Catorhintha, Stål.

C. mendica, Stål., (Kongl. Svenska Akad., IX, p. 187, No. 2.)—Brought from Colorado, and by Dr. E. Palmer from Fort Cobb, Indian Territory. It is much larger than *C. guttula*, Fab., to which it is very closely allied.

Ficana, Stål.

F. apicalis, Dallas, (British Museum List, II, p. 499.)—Specimens from Arizona and California have been examined by me; but no specimens happened to be brought home by the survey.

Anasa, Amyot et Serv

A. tristis, De Geer, (Mémoires, III, p. 340, Pl. 34, Fig. 20;) *Coreus ordinatus*, Say, (Jour. Acad. Phila., IV, 318, No. 2.)—This is the common squash-bug, so destructive of pumpkins and melons in various parts of the United States. It inhabits, also, Mexico, the West Indies, Central America, and Brazil. The present specimens were obtained by Dr. E. Palmer, at Fort Cobb, Indian Territory. The southern and western individuals occasionally exhibit a wonderful degree of variability in the shape of the pronotum. Specimens occur which have the lateral margins of that part either distinctly sinuated, with the humeri quite prominent, or the reverse, with the sides bowed and the humeri broadly rounded.

Alydus, Fab.

1. *A. eurinus*, Say, (Jour. Acad. Phila., IV, p. 324, No. 5;) *A. ater*, Dallas, (British Museum List, II, p. 478, 30.)—A common species in the eastern regions of the United States, as also in Nebraska and in Canada. It bears a very close relationship to *A. calcaratus*, Fab., of Europe; but in all the specimens of the European insect which I have yet seen the collum of the prothorax is very short, and the disk of the pronotum more robust and flattened than in our species. A careful comparison with the description of Mr. Dallas proves his *A. ater* to be only the female of our *A. eurinus*

2. *A. Pluto*. New species.—Intensely black, much more robust than *A. eurinus*, Say. Head more robust, minutely scabrous, pubescent; the constricted portion of the collum shorter; eyes and ocelli prominent; the intraorbital surface longitudinally impressed, almost to the line of the antennæ. Sides and under side of the head minutely granulated, punc-

tured, and wrinkled. Antennæ either piceous black, or black, with the bases of the first, second, and third joints pale piceous; the under side of base of the first joint whitish. Rostrum black, reaching to the intermediate coxæ. Pronotum very moderately convex, a little pubescent, coarsely, deeply punctured; the lateral margins slenderly carinated; the carina obsolete at the anterior angles, but considerably elevated on the moderately prominent posterior angles, and forming a sharp edge behind the humeri. Callosities, broad, large, bald, minutely granulated each side, with two impressed points behind their middle. Propleuræ coarsely, confluently, deeply punctured, except anteriorly, where the punctures are fine; meso- and metapleuræ rather coarsely, irregularly granulated, coarsely punctured behind and below. Legs deep black, pubescent, or with the anterior and intermediate tibiæ pale piceous on the middle; posterior femora with five curved spurs, from behind the middle to near the tip; at tip, with two or three close set, very small teeth; tarsi pale piceous on the base of the first joint. Scutellum coarsely, remotely punctured. Corium less coarsely, rather remotely punctured; embolium smooth, minutely, sparsely, obsoletely punctured, minutely pubescent; membrane brownish-black, with long, close, very numerous nervures. Tergum red as far as the base of the antepenultimate segment, or only a little red on two or three of the basal segments; venter deep black, shining, immaculate, very minutely shagreened, pubescent at tip.

Length to tip of venter, 12–13 millimeters; width across the humeri, 3 millimeters.

Inhabits Colorado; Ross Fork, Idaho; Louisiana; and Kansas. The spines of the posterior femora vary in number from three to six; this variation occasionally occurs on the opposite sides of the same specimen. There seem to be about twenty nervures to the membrane, of which two or three are usually forked.

Stachyocnemus, Stål.

S. apicalis, Dallas, (British Museum List, II, p. 479, No. 31.)—It inhabits Dakota, Texas, Mexico, and Florida.

Protenor, Stål.

P. Belfragei, Haglund, (Ent. Zeit., Stettin, 1868, p. 162.)—Brought from Colorado by the survey. It is found as far east as Maryland, and extends north into Michigan.

Neides, Latr.

1. *N. spinosus*, Say, (Amer. Ent., vol. I, Pl. 14;) *Neides trispinosus*, Hope, (Catal., p. 24.)—Brought from Ogden, Utah. It is common in the Atlantic region, and extends west into Arizona.

2. *N. decurvatus*, new species.—Form and general appearance of *N. spinosus*, Say. Luteous, or pale cinnamon-yellow. Head, with a slender decurved tooth projecting forward from the vertex. Pronotum proportionally more elongated, less coarsely punctured, the callosities at the anterior end of the median carina small and indistinct; the sternum dull black, no spines against the posterior coxæ; tip of the corium of hemelytra destitute of the dusky spot. Venter densely punctured.

Length, 7–9 millimeters; width across the humeri, $\frac{3}{4}$–1 millimeter.

Inhabits Colorado, Washington Territory, and New Hampshire.

Dasycoris, Dallas.

D. humilis. New species.—Closely resembling *D. pilicornis*, Burm., of Europe; but rather more slender; the head longer and the antennæ more slender. Fusco-cinereous, or pale fulvo-griseous, hispid; the head pale beneath; on the sides is a dark-brown stripe running from the antennæ to the base, tylus carinately elevated. Antennæ having the second joint distinctly shorter than the third; the fourth pale fuscous, conical, acuminate, not coarsely granulated and setose as the other joints, about equal to the third joint in length; antenniferous spines very short, small. Rostrum reaching to the intermediate coxæ; the tip piceous. Pronotum remotely punctured, beset with numerous granular processes, densely clothed with gray pubescence; the lateral margins, with their close-set, short, teeth-like processes, whitish; humeral angles with an acute, fuscous tooth, stouter and not so long as that in *D. pilicornis*. Pectus pale clay-yellow, or even whitish, closely, coarsely punctured, granulated, and with whitish, somewhat matted pubescence. Legs pale clay-yellow; the femora granulated, pubescent, mottled with brown; tibiæ darker at tip; the tarsi somewhat embrowned, and the nails piceous. Mesosternum blackish. Scutellum coarsely punctured, covered with dense, whitish pubescence; the tip white. Hemelytra beset with coarse, brown granules and short, whitish pubescence; the embolium grooved, flecked with brown; membrane pale, the nervures interruptedly brown. Connexivum with pale, transverse lines, between which are fuscous clouds. Venter minutely wrinkled, closely punctured; the pubescence minute, whitish; the basal segments having several brown points each side, and usually with a series on each side of all the segments; the lateral margins interruptedly infuscated.

The posterior femora usually have two spurs beneath, near the tip, and two or three small teeth close to the tip. Sometimes the two longitudinal nervures of the corium are interruptedly fuscous.

Length to tip of venter, $8\frac{1}{2}$–9 millimeters. Width across the humeri, 2–$2\frac{1}{4}$ millimeters.

Specimens have been collected in Colorado, Kansas, and California.

Harmostes, Burm.

H. reflexulus, Say, (Heteropt., New Harmony, p. 10, No. 1;) *H. costalis*, H. Schf., (Wanz. Ins., IX, p. 270, Fig. 992;) *H. virescens*, Dallas, (British Museum List, II, p. 520, No. 1.)—Brought by the survey from Colorado. The dark and also the red varieties seem to find their fullest coloring in the region adjacent to Maryland. The western specimens which I have hitherto examined have been chiefly of the pale-green type.

Aufeius, Stål.

A. impressicollis, Stål., (Kongl. Svenska Akad., vol. IX, p. 222.)—It inhabits Dakota, Arizona, California, and Texas.

Corizus, Fallen.

1. *C. borealis*, Uhler, (Proc. Acad., Phila., 1861, p. 284.).—This species is very variable in form and marking, and it may yet prove to be indentical with *C. punctiventris*, Dallas. It closely resembles *C. crassicornis*, Linn., of Europe. Thus far it has occurred in Colorado, Nebraska, Canada, and Massachusetts.

2. *C. lateralis*, Say, (Jour. Acad. Phila., IV, p. 320, 4.)—Obtained in Colorado; but quite common in the States east of the Mississippi River, and extending from British America to Florida, and west to Texas. In common with some other species, it has a race of individuals which are deeply suffused with red when alive.

3. *C. viridicatus*. New species.—Slender, form of *C. truncatus*, Ramb. Pale green; front of the face rather blunt, the end of the tylus decurved; upper surface of the head with whitish, sericeous pubescence, scabrous, uneven, minutely punctured; the under side obsoletely wrinkled, finely pubescent. Antennæ slender, clothed with remote long hairs; the basal joint extending beyond the tylus, freckled with dark brown, and usually with a short stripe on the under side; the apical joint rather slender, hardly longer than the preceding, more or less orange, at base paler; the second and third joints subequal, faintly streaked with brown both above and below. Rostrum reaching not quite to the posterior coxæ; the middle line and the apical joint, excepting at its base, dark piceous. Face and cranium sometimes with a few small spots and streaks of brown or black on the middle and near the eyes. Pronotum with long pubescence, coarsely punctured in irregular transverse rows, the callosities forming a prominent ridge nearly across the entire width; antepectus and pleura uneven, a little less coarsely punctured; the meso- and metapleuræ uneven, a little more coarsely punctured; the posterior flap of the metapleura oblique truncated, with the upper angle rounded at tip, and, together with the acetabular caps, minutely punctured. Legs greenish yellow, the femora rather robust, dotted with brown in rows, those of the upper, inward side sometimes confluent in a large patch; tibiæ freckled with brown; at tip and the tips of each of the tarsal joints brownish, the nails pisceous. Scutellum uneven, irregularly, somewhat coarsely punctured, the lateral edge recurved, the tip sunken, and its apex almost acute. Corium hyaline, rather finely punctured, the clavus sometimes blackish, or streaked with black; costal margin and base broadly coriaceous; the nervures usually with a few blackish points and streaks; membrane hyaline. Tergum black on the two or three basal segments, very coarsely punctured at base, and a little less coarsely on the disk; the apex with a black streak running from the penultimate segment to the tip, narrowing posteriorly; the antepenultimate segment often with two or three black dots on the disk; connexivum immaculate, minutely punctured. Venter immaculate, minutely wrinkled and shagreened, finely pubescent. The punctuation of the surface is sometimes brownish, either above, or both above and below.

Length, 5–6 millimeters; width across the humeri, $1\frac{3}{4}$–2 millimeters.

This species is quite unlike any of the others thus far discovered in the United States, in slenderness and neatness of proportions, as well as in the bright freshness of its colors when recent. It inhabits Colorado, Nebraska, and Dakota.

Leptocoris, Hahn.

L. trivitattus, Say, (Jour. Acad. Phila., IV, p. 332.)—A common species in Colorado, Arizona, and California.

Jadera, Stål.

J. hæmatoloma, H. Schf., (Wanz. Ins., VIII, Fig. 873.)—No specimens were collected by the survey, but it has been found in Arizona, Texas, Kansas, and California.

Family LYGÆIDÆ.

Lygæus, Fab.

1. *L. turcicus*, Fab., (Syst. Rhyng., p. 218, No. 61;) *L. reclivatus*, Say, (Jour. Acad. Phila., IV, p. 321.)—The form described as *L. reclivatus*, Say, differs from the Fabrician only in having the two white dots on the membrane. As specimens with this peculiarity occasionally hatch out of a cluster of eggs of the *L. turcicus*, laid on the pink *Asclepias* in Maryland, I do not hesitate to place it as a synonym of that species. Inhabits the United States generally.

2. *L. fasciatus*, Dallas, (British Museum List, II, p. 538, No. 17;) *L. aulicus*, H. Schf., (Wanz. Ins., VI, Fig. 646.)—Collected in Arizona, but common over the greater part of the United States east of the Sierra Nevadas, and extending from Canada to Central America and Brazil.

3. *L. bistriangularis*, Say, (Heteropt., New Harmony, p. 14, No. 3;) *L. marginellus*, Dallas, (British Museum List, II, p. 548, No. 51;) *L. vicinus*, Dallas, (ib., p. 549, 52.)—Inhabits Arizona, California, Texas, Mexico, Central America, and even Venezuela. The *L. marginellus* corresponds with the type described by Mr. Say; while the *L. vicinus*, Dallas, is the more common variety, which lacks the red lateral margins to the pronotum. Other varieties occur which have only a spot of red on the humeral angles; still others with simply a vestige of red on the posterior edge of the pronotum.

4. *L. facetus*, Say, (Heteropt., New Harmony, p. 13, No. 2;) *L. circumlitus*, Stål, (Entom. Zeit., Stettin, XXIII, p. 309.)—This pretty species was obtained by the survey in Colorado. It inhabits, also, Texas, California, Mexico, New Jersey, and Florida. Specimens from Cape Saint Lucas, Lower California, lack the red costal margin of the corium, and usually the red median stripe of the pronotum. The individuals from New Jersey exhibit among themselves a very perceptible variation in the proportionate obliquity of the sides of the pronotum.

5. *L. admirabilis*. New species.—Somewhat resembling the preceding, but with the pronotum more nearly quadrate, the sides not so oblique, and the antennæ proportionally more robust. Black, beneath grayish sericeous pubescent; the anterior margin of the pronotum, a short stripe on the base of the lateral margins, a short wedge-shaped streak on the base of the median line, inner margin of the clavus slenderly, and costal and posterior margins of the corium very broadly, red. Head a little longer than broad, much contracted before the eyes, minutely sericeous, grayish pubescent; antennæ very stout, almost as thick as the tylus, the basal joint extending a very little beyond the apex of the tylus; the second joint about the same length as the fourth; the third scarcely more than two-thirds of that length. Rostrum reaching behind the posterior coxæ. Pronotum remotely, minutely grayish pubescent, having a few shallow punctures behind the transverse ridge; the median ridge quite distinct; the humeral portion of the lateral margin thickened and elevated; sides of the antepectus with a few coarse, shallow punctures; the punctures of the mediopectus finer, almost obsolete; the upper posterior angle of the metapleura a little rounded. Hemelytra minutely sericeous pubescent; the posterior margin of the corium arcuated, sinuated on the middle; the membrane black, narrowly margined at base and all around with white, having four longitudinal nervures. Tergum red, the apical segments black; venter minutely sericeous pubescent; the pubescence on the posterior margin of the two apical segments longer.

Length to tip of venter, $4\frac{1}{2}$–5 millimeters. Width across the humeri, $1\frac{3}{4}$ millimeters.

Captured in Colorado.

6. *L. bicrucis*, Say, (Jour. Acad. Phila., IV, p. 322, No. 3.)—No specimens of this species were captured by the survey; but it inhabits a part of the territory passed over in Western Kansas, and is found also in New Mexico, Nevada, California, Texas, Florida, Maryland, and extends south into Mexico.

Nysius, Dallas.

1. *N. Californicus*, Stål., (Eugenies Resa omkring jorden, p. 242.)—Obtained in Colorado; it inhabits also Dakota, Arizona, and Texas, and one specimen has been collected by myself in Maryland, a few miles southwest of Baltimore.

2. *N. angustatus.* New species.—Dark gray, more slender than *N. thymi*, Wolff. Head moderately long, very minutely sericeous pubescent; the superior orbit of the eyes smooth, pale testaceous; the surface with coarse, partly confluent, brassy-black punctures; the median line of the tylus pale testaceous, its side brassy black; under side of head pale testaceous, blackish near the bucculæ, with remote coarse black punctures on the middle, and some finer ones around the base of the antennæ, and with a patch of fine black punctures posteriorly beneath the eye. Bucculæ smooth, pale testaceous; the rostrum piceous, reaching to the posterior coxæ. Antennæ moderately slender, the torulus testaceous, excepting only its base; basal joint testaceous, paler beneath; the tip and several dots on the upper side fuscous, the inner line dark piceous; remaining joints piceous, paler, and more rufescent beneath; the apical joint darker, not quite as long as the second; the second joint about one-fourth longer than the third. Pronotum narrowing anteriorly; the sides sinuated; surface pale testaceous, sericeous pubescent, coarsely punctured with brassy black in irregular, transverse rows; the callosities and surface before them blackish, more closely punctured, the anterior and posterior margins slenderly; the median line at base and the outside of the elevated humeri smooth, pale testaceous; pectoral surface sericeous pubescent, irregularly punctured with brassy black; the acetabular caps, gular collum, a broad stripe on the metapleura between two blackish ones, and the surface adjacent to the posterior coxæ pale testaceous. Legs testaceous; the femora with large brown dots; the tibiæ striped with brown, and somewhat brown at base and tip; tarsi brown on the apices of all the joints; the nails piceous. Scutellum pale testaceous, sericeous pubescent, having a few coarse black punctures; the median carina dark piceous, and the surface next to the tip blackish. Hemelytra very pale testaceous, very minutely punctured, sericeous pubescent; the posterior margin of the clavus and the nervures marked with interrupted brown streaks; costal margin slenderly; the outer end of the posterior margin of the corium and a streak on its middle, which bends abruptly inward and runs longitudinally about one-third way forward, brown; membrane very faintly brownish, marked with a few brown clouds. Tergum piceous-black; the incisures of the segments, the sides of the fourth, fifth, and sixth segments, and a spot each side of the terminal segment rufo-testaceous; connexivum margined with, and at the incisures spotted with, testaceous. Venter griseous, minutely, uniformly sericeous pubescent; the second and third segments with a transverse series of a few very black points; the disk of the fifth and base of disk of the sixth segment yellow, with an interrupted black stripe on

the middle; the sides of these segments and of the one next in front have a very black line, which is interrupted at the incisures, (sometimes this line runs along the whole length of the venter, continuous with that on the metapleura;) the apical segment more or less yellow each side; the lateral margins yellowish, and the submargin with short, black, remote lines, and with similar oblique ones, lower down, on the sides of three or four basal segments; male. The female is paler, with the middle joints of the antennæ pale rufous, excepting at base and tip, with the venter pale testaceous, and the base and a lateral, broad, and another narrower vitta, blackish.

Length to tip of venter, 4–5 millimeters. Width across the humeri, $1\frac{1}{4}$ millimeters. Brought from Colorado; it inhabits also Dakota and Canada.

The pronotum is about one-fifth wider than long, and the metapleura is very remotely, shallowly punctured, and often rufo-flavous, particularly in the females.

Ophthalmicus, Schill.

O. piceus, Say, (Heteropt., New Harmony, p. 18, No. 1.)—Obtained in Colorado; but is quite a common insect in the Atlantic region.

Emblethis, Fieb.

E. arenarius, Linn., (Fauna Suecica, p. 955.)—Obtained at Cheyenne, in August. The specimens from our Western Territories seem to correspond very closely with those of Europe.

Rhyparochromus, Curtis.

R. fallax, Say, (Heteropt., New Harmony, p. 17, No. 6.)—Brought from Colorado and Montana; but quite common in Illinois, New England, Canada, British Columbia, and even in California.

Plociomerus, Amyot et Serv.

P. diffusus, Uhler, (Proc. Boston Soc. Nat. Hist., 1871, p. 9.)—Collected in Colorado. It is widely diffused in the Western United States, and extends as far east as Maryland.

Heræus, Stål.

H. insignis. New species.—Similar in form to *Araphe Carolina*, H. Schf. Shining black, or with the head, thorax, and legs pale rufo-piceous. Anterior lobe of the pronotum very high and convex. Head longer than wide, subconical, very convex above, minutely granulated, pubescent, and with a few erect, long hairs. Rostrum extending upon the intermediate coxæ, piceo-rufous, with the third and fourth joints blackish piceous. Antennæ fulvous, or rufo-flavous; the fourth joint and apex of the third blackish, these two subequal in length; the second joint much the longest; the basal one extending a little beyond the tip of the tylus, armed beneath with a few long bristly hairs. Pronotum polished, the anterior lobe almost sphæro-convex, very minutely scabrous, and with a few erect long hairs; against the collum is a transverse, impressed, punctured line; the posterior lobe abruptly slanting anteriorly, remotely, coarsely punctured with black on a pale piceous

ground; the incisure dividing the lobes very deep; humeri tumidly prominent; under side of the collum coarsely punctured; the pleura minutely roughened; the acetabular caps, anterior margin of collum, and posterior margin of the metapleura white. Legs piceous; the tibiæ usually paler, with the anterior femora stout, and armed beneath with about four short spines, and along the whole length with remote, long hairs. Scutellum piceous or rufo-piceous, long and very acute, remotely punctured. Hemelytra pale testaceous, punctured with blackish, in longitudinal series; a large black spot occupies from the middle to the tip, with a subtriangular, testaceous spot thereon near the tip; the costal and posterior margins of the corium pale testaceous; disk of the clavus more or less black; the membrane dusky; wings white. Tergum black, or with piceous at base; venter black, finely sericeous pubescent; the second segment has a minute, geminate tubercle each side of the middle, in both sexes.

Length to tip of venter, 5–6 millimeters. Width across the humeri, 1–1⅛ millimeters.

Inhabits Ogden, Utah; Colorado; Canada; and Minnesota. It varies greatly in the length of the hemelytra, which are either much shorter or somewhat longer than the abdomen. The head is not wider than long, as Dr. Herrich-Schäffer describes his Araphe to be; but in most other respects our insect seems to be near that genus.

Plociomerus, Amyot et Serv.

P. diffusus, Uhler, (Proceed. Boston Soc. Nat. Hist., 1871, p. 9, No. 2.)—Collected in Colorado by the survey; but it is quite common in the Eastern United States and Canada. In Maryland and Massachusetts, I have found it on low spots in grassy meadows.

Family LARGIDÆ.

Largus, Hahn.

L. succinctus, Linn., (Cent. Insect. Rariorum, p. 17, No. 44.)—Brought from Colorado by the survey. It inhabits all the Atlantic region, from New Jersey to Florida, and extends westwardly through Texas and Indian Territory, as far as into Arizona.

Family PHYTOCORIDÆ.

Megalocerœa, Fieb.

1. *M. debilis.* New species.—Yellowish or greenish-white, polished. Head impunctured, the middle line incised, each side with a black line running from before the torulus to the base, and continued on the pronotum to its base; eyes brown, tylus sometimes black anteriorly; antennæ long, the basal joint blackish, bald, sometimes paler inwardly, a little stouter than the second, about as long as the pronotum; the second piceous, about as long as the head, pronotum and scutellum united; the third a little paler, abruptly more slender, about two-thirds as long as the second; fourth hardly as long as the basal joint. Sometimes the antennæ are orange-yellow, excepting the first joint and base of the second. Rostrum reaching to the venter, the tip piceous. Pronotum irregularly, remotely, somewhat coarsely punctured, the lateral carinate edge smooth, as is also the median line; propleura roughly punctured, usually having a broad, black stripe which runs back, more slenderly, to the end of the venter. Mesosternum and coxæ more or less orange.

Legs pale greenish, more or less embrowned on the tarsal joints and tip of the tibiæ; the femora with impressed, sometimes brownish, points in series. Scutellum yellow, margined at base with black, minutely transversely wrinkled, having a few obsolete punctures. Hemelytra longer than the abdomen; the corium pale yellowish, or with the disk dusky and the margins yellowish; membrane whitish, with the nervule brownish. Abdomen pale yellowish, the disk of the tergum more or less brownish, or sometimes with black bands on the segments; venter usually having the lateral black lines very distinct.

Length to tip of venter, 5–6 millimeters. Width across the humeri, 1½ millimeters.

Inhabits Berthoud Pass and other parts of Colorado; also Montana, Cheyenne, &c.

2. *M. rubicunda.* New species.—Form similar to *M. debilis;* rosy or crimson-red. Head bald, pale, rosy, or yellowish, with a black dot each side of the middle, between the eyes, and a broad, black stripe each side, invaded by the eyes, which, running forward, curves downward at the antennæ and covers the tylus; throat blackish. Antennæ black, slender; the second joint a little longer than the head pronotum and scutellum united, basal and apical joints subequal; the third joint a little longer than the fourth. Rostrum pale yellow, reaching to the third ventral segment; the apical joint piceous, excepting at the base. Pronotum testaceous, tinged with rosy, irregularly punctured with black; the middle line and sides pale; each side, near the anterior angles, with a subquadrate black spot; the lateral margins feebly sinuated, and the posterior angles broadly rounded. Pectus yellow, with rosy nebulæ; the propleura remotely punctured and with a black spot anteriorly; meso- and metapleuræ each with a large, long, black spot; sternum, and sometimes a spot near the base of the coxæ, black. Legs pale yellow, the femora dotted with dark brown, and with the spines and tip of tibiæ piceous; tarsi dark piceous. Scutellum rosy, yellow at tip, black at base, and with a red stripe along the middle. Hemelytra rosy, obsoletely scabrous, remotely punctured, and with a few lines of punctures near the sutures; the margins of corium and clavus and the longitudidal nervures yellowish; membrane pale brown; the nervule yellow, or sometimes reddish at base; wings faintly brown. Tergum more or less blackish, at base reddish, and with the apical segment yellow, except at the base; the connexivum yellow, defined inwardly by a dark line; venter yellow, rosy on the sides, and with a red line along the middle; the inferior connexivum yellow, bounded on the inner side by a line of interrupted, impressed, slightly oblique, black streaks. Bases of venter and anal segment sometimes blackish.

Length to tip of venter, 4½–5 millimeters; width across the humeri, 1½–1¾ millimeters.

Brought from Colorado. The amount of black on the head, &c., varies very considerably.

Trigonotylus, Fieber.

T. ruficornis, Fallen; Herrich-Schf., (Wanz. Ins., II, p. 119, Fig. 200.)—Obtained at Snake River, Idaho, and Colorado. It extends east as far as Maryland and Massachusetts. In the latter State it abounds upon the salt-marshes near the coast.

Leptopterna, Fieber.

L. amœna. New species.—Robust, pale yellowish; head and antennæ stouter than in *L. dolobrata*, Linn., with the pronotum long, and narrower

behind than in that species. Head yellowish, pubescent, indented posteriorly, having a Λ-shaped black mark between the eyes, the tip of tylus, a spot behind the eyes, a partial circle around the eyes, and a few dots on the genæ, black. Antennæ fulvous, densely beset with blackish, erect, stiff pile; the basal joint very thick, a little longer than the pronotum; second joint a little more slender, tapering toward the tip, as long as the distance from the tip of head to the second ventral segment; third joint slender, a little longer than the basal one; apical joint still more slender, less than one-half the length of the third. Rostrum reaching to the posterior coxæ, pale yellow; the apical joint piceous, excepting only at base. Pronotum not much widened posteriorly; yellowish, with a dark line each side, and black spot; the lateral margins narrowly reflexed, faintly sinuated; the surface having three or four transverse, impressed lines, and behind the collum with an obsolete, collar-like ridge. Pectus yellow, a pale-brown stripe on the propleura, and a few brown marks on the middle and posterior areas and coxæ. Legs lost from the specimens. Scutellum yellow, with a triangular black mark each side near the base. Hemelytra shorter than the abdomen, yellow, with a long, large, dusky cloud on the disk; membrane whitish, with the nervule dusky. Tergum more or less saturated with reddish or brown on the sides of the segments; venter yellow, pubescent, with pale-brown spots each side, which include an impressed, short, black line on each of the segments, excepting the anal one. ♀

Length to tip of venter, 8 millimeters; width across the humeri, $1\frac{1}{2}$–$1\frac{3}{4}$ millimeters.

Inhabits the vicinity of Snake River, Idaho. A poor specimen from Dakota, in my own collection, has much shorter hemelytra than that brought home by the survey.

Calocoris, Fieber.

1. *C. rapidus*, Say, (Heteropt., New Harmony, p. 20, No. 4;) *Capsus multicolor*, H. Schf., (Wanz. Ins. VIII, p. 19, Fig. 795.)—Brought from Colorado. The reddish variety extends as far west as San Francisco. Western specimens exhibit much difference in colors and pattern of marking; while in several parts of the Atlantic region a singularly exact uniformity of color prevails.

2. *C. Palmeri*. New species.—Form similar to *C. bipunctatus*, Fab. Bright, deep yellow, polished. Head smooth, impunctured, clothed with long, remote hairs, the vertex having a broad, rounded indentation, and the cranium exhibiting traces of oblique striæ each side, running from a central line; eyes brown, with the orbits more or less yellow; the occiput, throat, tylus, antennæ and rostrum black; or with the cranium and face black, excepting only the cheeks and a spot on the middle. Antennæ as long as from the tylus to the tip of cuneus; the second joint as long as the pronotum and scutellum united, cylindrical, a very little more slender at base than tip; the third and fourth joints together about two-thirds the length of the second; the third a little longer than the fourth, both slenderly tapering to the tip; rostrum reaching to behind the posterior coxæ; the second and fourth joints longer than the basal one, subequal in length; the third very much shorter than the basal one. Pronotum moderately convex, coarsely, obsoletely punctured, with remote, erect hairs; sides oblique, straight; the disk with two round black dots, or with an irregularly subquadrate spot on the middle, or with a transverse spot in front

and behind, connected by longitudinal stripes. Propleura coarsely punctured, yellow, with a long black spot; the posterior pieces and coxæ more or less black. Legs yellow; the knees, base and tip of tibæ and tarsi all over black. Scutellum yellow or black, transversely wrinkled. Hemelytra yellow, rather coarsely, closely punctured, and transversely wrinkled; the inner margin of the cuneus, and a more or less large spot near the end of the corium, black; membrane almost black; the nervule deep black. Venter black, or pale yellow, with the margins of the segments white, pubescent; ovipositor black.

Length to tip of venter, 5–6 millimeters; width across the humeri, $2\frac{3}{4}$–3 millimeters.

It inhabits Arizona, and was obtained by Dr. E. Palmer, to whom the species is respectfully dedicated.

Resthenia, Amyot et Serv.

1. *R. insignis*, Say, (Heteropt., New Harmony, p. 22, No. 12.)—Collected in Colorado; but it occurs also in New England, Illinois, and in the Middle States. The species is very unstable in colors and pattern of marking, varying from red with black spots to almost uniform black.

2. *R. confraterna*. New species.—Form similar to *R. insitiva*, Say, but with the pronotum a little narrower and longer; prevailing color black, opaque. Head convex, blood-red, with a large, more or less rounded, spot on the disk; a small spot at tip of the inferior gena, and the surface of the tylus black; rostrum reaching to the venter, piceous or blackish. Antennæ black, pubescent, about as long as the hemelytra, slenderly tapering to the tip; the apical joint longer than the basal one, but much shorter than the third; second as long as the pronotum and scutellum united. Pronotum crimson-red, one-third wider than long, having a blackish, broad stripe along the disk, widened posteriorly, or with a large rounded spot from the base to before the middle. Pectus red; the sternum and trochanters dusky; legs blackish; the coxæ yellowish. Scutellum black, or reddish only at base. Hemelytra entirely black, longer than the abdomen. Venter red, pubescent; usually more or less dusky on the disk.

Length to tip of venter, 6–$6\frac{1}{2}$ millimeters; width across the humeri, $2\frac{3}{4}$ millimeters.

Inhabits Colorado, Wisconsin, Illinois, Pennsylvania, and Maryland. The collum of the pronotum is broad, as in *R. insitiva*, Say.

Lopidea, Uhler.

Elongate-oval, the sides of hemelytra parallel. Head vertical, from the front to the occiput short; face transverse, fully twice as broad as long, the front raised on the middle, the sides near the eyes correspondingly depressed; eyes subhemispherical, prominent; occiput transversely impressed, the carina higher in the middle; antennæ placed just below the line of the eyes, in length almost equal to the pronotum and hemelytra united; the basal joint about equal to the breadth between the eyes; second joint three times as long as the first; third about two-thirds the length of the second; tylus vertical above, then curving inward below; the superior cheeks small, elongate-quadrate; rostrum reaching to the intermediate coxæ, basal and second joints about equal in length, third shorter than the second, the apical one subequal to the preceding. Pronotum trapezoidal, about one-half wider than long; the lateral edges carinately elevated; the middle of posterior margin sinuated, deflexed;

callosities oval, placed obliquely. Suture between corium and cuneus externally deeply notched; areole of the membrane obliquely narrowed toward the outer end.

L. media, Say, (Heteropt., New Harmony, p. 22, No. 11;) *Capsus Robiniæ*, Uhler, (Proc. Ent. Soc., vol. I, p. 24.)—This species seems to inhabit almost the whole territory of the United States. The present specimens came from Cheyenne, and were collected in August, 1870. The yellow variety, named *C. Robiniæ*, dwells upon *Robinia pseudacacia*.

Hadronema, Uhler.

Aspect of *Lopus*: cranium somewhat convex, face almost vertical; eyes prominent, oval, almost vertical; occiput with a high, transverse carina between the eyes; tylus a little prominent, narrowing toward the tip; cheeks short and blunt; bucculæ narrow, shorter than the basal joint of the rostrum; that joint subcylindrical, robust, a little longer than the head. Antennæ short, about as long as the corium and cuneus united, stout; the third and fourth joints of nearly equal thickness, not tapering to a setaceous termination; the latter less than one-half the length of the preceding. Pronotum trapezoidal; the angles rounded; the collum forming an obtuse, narrow collar, and behind it is an arcuated carina abbreviated a little way from the lateral margins; the lateral edges prominently carinated. Costal margins of the hemelytra almost straight, parallel.

H. militaris. New species.—Black, dull, more or less tinged with cinereous. Head broad, dull black, having a few stiff hairs on the vertex, and with yellowish pubescence about the tip of the tylus; bucculæ yellow; rostrum and antennæ black, the former reaching to the intermediate coxæ; antennæ sparingly setulose; the joints closely united; the basal joint short, reaching a little way beyond the head; second longest, not quite as stout as the basal, and more than twice as long; third joint a very little more slender than the second and about one-fourth shorter; the apical one a little more slender, but not setaceous, a little longer than the basal; these two last densely covered with golden-yellow pubescence. Pronotum rather flat, yellowish-red, the anterior lobe black, and sometimes that color extends backward on the middle, invested with black, remote, bristly hairs; the posterior lobe coarsely, transversely rugose, the carinated lateral edge a little sinuated; the anterior angles rounded and posterior ones more broadly so, and having the edge a little raised; propleura red posteriorly, smooth; the remainder of the pectus, and the legs, bluish-black, the latter with yellowish pubescence; posterior femora with a row of obsolete blacker points. Scutellum a little scooped out upon the middle. Corium black, the costal margin broadly yellowish-white, invested with remote erect setæ; the cuneus yellow, except on the inner part of base; membrane pale fuscous, with the nervule black. Abdomen dull bluish-black, invested with yellowish, minute pubescence; the upper margins broadly red on the middle, more narrowly so at tip.

Length to tip of venter, $3\frac{1}{2}$–5 millimeters. Width across the humeri, $1\frac{1}{2}$–$1\frac{3}{4}$ millimeters.

Inhabits Colorado; Ogden, Utah; California; also found at Cheyenne, in June, 1869.

The specimens vary in the width of the pale margin of the hemelytra and in the extent of black on the pronotum. The base of the corium is sometimes entirely whitish.

Lygus, Hahn.

1. *L. lineolaris*, Palisot de Beauv., (Ins. Afr. et Amer., p. 187, pl. xi, Fig. 7.) *Capsus oblineatus*, Say, (Heteropt., New Harmony, p. 21, No. 7.)—Obtained in Colorado. It inhabits almost the whole territory of the United States, and is common in Canada and British America. The specimens from the western sections exhibit a number of dark varieties thus far not met with on the Atlantic slope of the continent. This species includes the two extreme races to which I had provisionally given the names *L. redimitus* and *L. diffusus;* but these names must be dropped, as thus they do not belong to true species. A specimen was collected at Cheyenne in August, 1870.

2. *L. annexus*. New species.—Closely allied to the preceding species, but having the pronotum longer and narrower and the punctures closer and finer. Fusco-griseous, or grayish-testaceous, sericeous pubescent. Head minutely, sparingly punctured, indented on the middle of the vertex; testaceous, with the tylus and each side of face piceous, or piceous with a median yellow stripe and with marks of yellow each side of the tylus; occiput with a transverse carina. Antennæ slender, piceous, or black, or even pale rufo-piceous, with the ends of the joints darker, the apical joint much shorter than the preceding one. Rostrum reaching to the posterior coxæ, testaceous, with a black apex. Pronotum blackish-piceous, or grayish-testaceous, coarsely rugose, closely and somewhat finely punctured between the rugæ; the lateral margins feebly sinuated; the posterior margin arcuated, testaceous; callosities smooth, prominent; the collum distinctly defined, testaceous. Propleura piceous, rugose, and closely punctured; the inferior margin pale yellow; pectus, coxæ, and base of femora pale yellow; the upper part of pleuræ having a broad black stripe, which is continued along the venter to the tip. Femora dusky or piceous at tip; the tibiæ more or less suffused with pale piceous; the tarsi and nails dark piceous. Scutellum rufo-piceous, piceous, or grayish, densely yellowish pubescent, transversely wrinkled, and having only a very few obsolete punctures; the tip smooth, pale yellow. Hemelytra very minutely scabrous, obsoletely punctured, closely yellowish pubescent; the costal margin straight, color brownish, piceous, or testaceous, clouded with brown on the disk and clavus; the inner apex of the corium having a thickened, short, linear, whitish margin; cuneus long, testaceous, with a dusky tip, sometimes suffused with rufous; membrane very long, smoke-brown, with the nervule pale testaceous. Venter testaceous, smooth, shining, closely pubescent, the last segment more or less piceous. Sometimes all beneath, except the propleura, is pale testaceous. ♂ ♀.

Length to tip of venter, $4\frac{1}{2}$–5 millimeters. Width across the humeri, $1\frac{3}{4}$–2 millimeters.

Collected in Colorado.

Dacota, Uhler.

Allied to *Polymerus*, Fieber. Form long-ovate; head declining anteriorly, longer than wide, and together with the eyes only a little wider than the front of the pronotum; the tylus narrowing almost to an acute tip; eyes large, oval, almost vertical; the superior cheeks with a recurved lower margin; bucculæ forming a narrow strip along the anterior half of the gula. Apical joint of rostrum long and very slender; antennæ as long as the thorax and abdomen united; the first joint longer than the head, constricted at base; the second about three times the length

of the first, obfusiform; the apical joints abruptly more slender. Pronotum trapezoidal, fully twice as wide as long; the osteolar orifice large; the scale in which it is inserted is subpyriform in outline. Hemelytra wider posteriorly; the costal margins arcuated and the edge elevated.

D. hesperia. New species.—Long-ovate, dull black, invested all over with gray, prostrate pubescence. Head long, without the eyes very much narrower than the front of pronotum, obsoletely, minutely wrinkled; the face slanting downward, moderately convex; the occiput having a feeble and very slender carina across its width; eyes brown; antennæ black; the basal joint about one-third the length of the second; the second a little longer than the head and pronotum united, gradually thickened from the middle to the tip; the third and fourth much more slender; the third about one-half the length of the second; the fourth hardly more than one-half that of the third. Rostrum yellowish-piceous, reaching behind the posterior coxæ; the apical joint very slender and much longer than the third joint; bucculæ yellowish. Pronotum a little transverse, moderately convex; the sides oblique, not carinated, a little arcuated; the surface minutely wrinkled, densely coated with grayish pubescence; the callosities a little convex, defined posteriorly by an impressed line; anterior margin almost straight, fitting very closely against the head, with a feebly defined collum; posterior angles rounded; the posterior margin a little sinuated. Propleura wrinkled, and, together with the rest of the pectus, densely grayish pubescent. Legs lurid rufous, minutely pubescent; the coxæ, tarsi, and tip of tibæ blackish. Scutellum transversely wrinkled, very slightly convex. Hemelytra almost flat, densely scabrous, closely grayish pubescent; the costal margin much elevated, arcuated; the clavus large and wide; membrane blackish. Venter black, polished, minutely sericeous pubescent.

Length to tip of venter, $4\frac{1}{2}$ millimeters. Width across the humeri, $2\frac{1}{4}$ millimeters.

Inhabits Colorado and Dakota.

Pœciloscytus, Fieber.

1. *P. venaticus.* New species.—Rather less robust than *Charagochilus Gyllenhali*, Fieber. Dull black, closely, minutely, yellowish pubescent. Head black, densely pubescent, face moderately convex; the cranium with a yellow spot against each eye; occipital carina slender, sharp. Antennæ black, stout, the basal joint extending a little beyond the tip of tylus; second joint a little stouter at tip, about as long as the pronotum and scutellum united; the third joint abruptly more slender, about the same length as the basal one; the apical joint subequal to the preceding, and a very little more slender. Pronotum moderately convex, black, minutely, closely punctured, and obsoletely wrinkled, coated with sparse, yellowish pubescence, a little depressed between the callosities; the posterior margin arcuated; the edge yellow; lateral margin oblique, straight. Pectus black, pubescent, with the posterior and inferior margins slenderly yellow. Legs black, minutely pubescent; the coxæ, base of femora, and basal and middle joint of tarsi yellow. Scutellum a little convex, minutely, transversely wrinkled, coated with yellowish pubescence. Hemelytra longest in the male, black, yellowish pubescent, minutely scabrous, closely punctured; the cuneus, and sometimes the costal margin, red or yellow; the membrane blackish, with the nervule more or less yellow. Abdomen black, sericeous pubescent; the posterior edges of the segments sometimes whitish.

Length to tip of venter, $3\frac{1}{2}$–5 millimeters; width across the humeri, 2–$2\frac{1}{4}$ millimeters.

Brought from Colorado by the survey; but specimens have been collected also in California, Illinois, and Massachusetts.

2. *P. diffusus.* New species.—More slender than *P. venaticus.* Black, densely coated all over with prostrate, whitish pubescence. Cranium very convex, with a spot against each eye; the upper cheek and bucculæ yellow; antennæ black, slender, reaching a little behind the middle of the corium; second joint cylindrical, longer than the third and fourth united; the third and fourth more slender, subequal. Rostrum reaching to behind the intermediate coxæ, piceous, with the basal joint yellow. Pronotum minutely rugulose, convex, margined on the sides and behind with yellow; the posterior angles widely rounded. Pectus yellow, sericeous pubescent, black on the upper part of the disk of the pleural segments; coxæ yellow. (Legs lost from the specimens.) Scutellum with a yellow tip; hemelytra broadly margined with pale yellow; the cuneus either yellow, or with a dusky disk; the thickened, line-like, inner margin of the apex of corium yellow; membrane dusky; the nervule yellowish. Abdomen all over black, or with the venter yellow, and having the disk and broad lateral stripe black.

Length to tip of venter, 3–4 millimeters; width across the humeri, $1\frac{1}{2}$–2 millimeters.

Brought from Ogden, Utah, by the survey. The male is much longer and more slender than the female, and has the hemelytra very much longer than the abdomen.

Rhopalotomus, Fieber.

1. *R. Pacificus.* New species.—Elongated, black, shining, grayish sericeous pubescent. Face very convex, densely pubescent; the sides with a small fovea in front of the eyes; the occiput tranversely tumid, scabrous; eyes brown, very prominent, their posterior orbits encircled with yellow; margin and tip of the tylus, lower end of the upper cheeks, upper margin and tip of the lower cheeks, torulus and base of the second joint of the antennæ, and inner portion of the basal joint of rostrum orange. Antennæ black, bald, long, reaching beyond the tip of the corium, slenderly tapering to the tip; the basal joint a little curved, longer than the head; second joint longest, longer than the head and pronotum united; third a little less than one-half as long as the second; the fourth considerably shorter than the third. Rostrum more or less yellow, reaching beyond the intermediate coxæ; the labrum and outer surface piceous, and the apex blackish-piceous. Pronotum long and narrow, transversely wrinkled, scabrous; the sides sinuated; the collum slenderly carinated, and the humeral angles a little arcuated. Pectus dull black; the propleura scabrous; all the pieces, except the posterior one, margined below and behind with yellow; coxal ends and the osteolar segment also pale yellow. Scutellum scabrous, transversely wrinkled, sparsely pubescent. Hemelytra roughly shagreened, sparingly pubescent; the thick nervure brown at the extreme base; membrane pale brown; the nervule sometimes fulvous. Venter dull black, tinged with cinereous; the superior connexivum shagreened, margined with dull yellow. ♂ ♀.

Length to tip of venter, 5–6 millimeters; width across the humeri, 2 millimeters.

The legs are usually yellowish, the femora striped and sparingly spotted with black, the knees and tip of tibiæ and the tarsi blackish.

It inhabits Montana, and near Snake River, in Idaho. Several specimens have also been collected in California.

2. *R. brachycerus*. New species.—Shorter and more robust than *R. Pacificus*. Shining black, clothed with longer pubescence, which is dense and erect on the head. Head not so long as in *R. Pacificus*; the surface scabrous; the cranium a little depressed, and with a shallow, longitudinal groove on the middle; the anterior margin of the lower cheeks yellowish; eyes brown; the posterior lobe of the eyes black, encircled with yellow; antennæ black, not reaching quite as far as to the base of cuneus; the torulus yellow at base; second joint but little more slender than the basal one, about as long as the pronotum; third and fourth joints subequal; rostrum reaching upon the posterior coxæ, yellowish; the fourth joint and base of the third piceous; third joint very short, but little more than one-half the length of the fourth. Pronotum short and wide, coarsely scabrous, densely punctured and wrinkled, having close, long pubescence; the lateral margins broadly sinuated; callosities distinctly elevated, excavated anteriorly; humeri a little prominent; the margin exterior to them rather broadly rounded. Scutellum coarsely wrinkled, very sparingly punctured; apical half of coxæ and lower margins of the pleural segments yellowish white; propleura very coarsely, roughly punctured. (Legs lost from the specimens.) Hemelytra longer than the abdomen, scabrous, closely punctured; the pubescence moderately dense, long, prostrate; cuneus much shorter than in *R. Pacificus*; membrane brown, or blackish fuliginous; the nervule black. Venter highly polished, very minutely, obsoletely wrinkled, sparingly pubescent.

Length to tip of venter, 4½–5 millimeters. Width across the humeri, 2–2½ millimeters.

Inhabits Weld County, Colorado. A closely related, if not identical, species is found on the island of Santa Cruz, California.

Labops, Burm.

L. hesperius. New species.—Black, opaque. Head bluntly triangular, much stouter than in *L. Sahlbergi*, Fallen; the face yellow, shining, having a large, irregular, black circle on the middle, which throws off a branch posteriorly and another toward each eye; the throat, tylus, and ends of cheeks also black. Eyes stouter and, together with the peduncle, shorter and less prominent than in *L. Sahlbergi*. Antennæ black, slender, almost setaceous at tip; the second joint a little longer than the third and fourth united; third and fourth subequal in length, the former tapering toward the tip; rostrum reaching to the posterior coxæ, blackish-piceous, the basal joint more or less yellow. Pronotum transversely wrinkled, invested with grayish, prostrate pubescence, and laterally with erect hairs; the anterior side a little narrower than the space between the eyes; lateral margins slightly sinuated; the callosities elevated, smooth; behind them is a transverse, impressed line. Pectus with grayish pubescence; the inferior margins of the pleural pieces yellowish. Legs black; the apex of the femora and base and apex of the coxæ orange-yellow. Scutellum and hemelytra with grayish, prostrate pubescence; the corium arcuated and gradually widened posteriorly; the exterior margin of corium and cuneus pale yellow; membrane smoke-brown, with the nervule black. Abdomen densely sericeous pubescent, with the surface next the ovipositor more or less yellowish; the posterior segments more or less hairy.

Length to tip of venter, 3½–5 millimeters. Width across the humeri, 1½–1¾ millimeters.

Brought from Colorado and Montana. Specimens were collected by Robert Kennicott in the vicinity of Lake Winnepeg and near Great Bear Lake, in British America.

Camptobrochis, Fieber.

C. nebulosus. New species.—Form and general appearance of *C. punctulatus*, Fallen. Pale olivaceo-testaceous, ovate, robust, polished, coarsely punctured. Head black, polished, impunctured; the transverse groove in front of the basal carina deep; the carina, a streak adjoining each eye, a short one on the middle of the face, another on the tylus, and one each side of it pale yellow; antennæ with short, hoary pubescence; the basal joint black, polished; the second piceous yellow, obscured at base and tip; third and fourth obscurely piceous yellow; bucculæ and setæ yellow; the rostral sheath more or less piceous, paler on the basal joint. Pronotum grayish-testaceous, regularly convex, with deep, remote, black punctures, which are confluent near the sides; a large black cloud on the disk, and several vestiges about the sides and near the posterior margin; callosities black, smooth, very slightly elevated; collum, lateral carinæ, and posterior edge yellow; the lateral margins sinuated, deflexed, carinate on the edge; posterior margin broadly rounded; feebly sinuated on the middle and also adjoining the humeri; the humeral angles a little raised, broadly rounded; anterior angles almost rectangular; pleuræ black margined, with yellowish, and together with the anterior xyphus deeply, confluently punctured. Sternum dull black, posteriorly margined with yellow; the odoriferous glands pale yellow. Femora black, remotely whitish pubescent, obsoletely punctured, at tip pale yellow; the knees with a black spot, tibiæ pale yellow, with two piceous-black rings a short distance below the knees and another at tip; tarsi pale yellow, more or less piceous at base and tip; the nails blackish. Scutellum blackish-piceous, confluently punctured, except at tip; each side of the base and on the apex is an ivory-yellowish spot. Hemelytra olive-testaceous, remotely punctured with brown; the costal edge, base, tip exteriorly, several large and occasionally coalescing spots beyond the middle and base, interior edge and apex of the clavus and interior corner and apex of the cuneus dark brown; cuneus broad, short, acute, sharply incised at base; membrane transparent; the nervures of the areole, the middle of their margin, a small spot beyond, and a vestige at base brown. Venter black, polished, remotely, minutely yellowish pubescent, finely, remotely, obsoletely punctured; genital pieces of the female piceous.

Length, 3½–4 millimeters. Width across the humeri, 1½ millimeters.

Tinicephalus, Fieber.

T. simplex, new species.—Pale green, opaque, rather robust, minutely, densely pubescent. Head broad and short; cranium convex; the base of tylus and each side of middle dusky; antennæ piceous; the basal joint blackish; second joint slender, of uniform thickness throughout, length equal to that of the pronotum and scutellum united; third joint about two-thirds the length of the second, and about twice the length of the apical joint; the two last gradually tapering to the tip; rostrum reaching to the intermediate coxæ, the tip piceous. Pronotum trapezoidal, transverse, impunctured; the callosities covered by a blackish,

transverse stripe; lateral margins regularly curving toward the head. Legs pale greenish, or with dark tips to the tibiæ and tarsal joints. Scutellum yellow in some specimens. Hemelytra with longer, erect hairs about the base and costal margin; the membrane brown, with the costal nervule black. Tergum black, with the connexivum and apex of the anal segment green; venter yellowish, densely whitish sericeous; pubescent.

Length to tip of venter, 3 millimeters; width across the humeri, $1\frac{1}{2}$ millimeters.

Collected in Colorado.

Plagiognathus, Fieber.

P. obscurus, new species.—Elongate aval, dull black or fuscous, clothed with yellowish pubescence. Head black, or blackish piceous, the occipital ridge pale; face moderately convex, obliquely inclining, smooth, sparingly pubescent; tylus abruptly prominent, black; cheeks black; the gula black; bucculæ margined with yellow; labrum and setæ yellow; the rostrum yellow or pale piceous, shining, reaching a little beyond the posterior coxæ; the basal joint black, a little longer than the head; antennæ black, or blackish fuscous, minutely hairy; basal joint yellow at tip; the third and fourth joints paler than the others. Pronotum broader than long, polished, obsoletely wrinkled, slightly more closely pubescent in the males than in the females; humeral angles a little prominent, subacute; posterior margin regularly bowed, the edge deflexed; lateral margins oblique, hardly sinuated; the sides steeply declining, with the carinate edge blunt; anterior submargin collar-like, sinuated in the middle; the callosities very slightly elevated, broad and long, coalescing inwardly. Pectus piceous or black, bald, shining; edges of the anterior acetabulæ and xyphus, meso-pleural piece, tegula, and surface adjacent to the posterior acetabulæ more or less yellow; legs, including the coxæ, bright yellow, sometimes tinged with piceous; the anterior and intermediate femora slightly sprinkled with brown near the tip, and on the inner and outer surfaces with a few brown dots; knees with a black dot; tarsi more or less piceous at base and tip; nails black. Scutellum minutely obsoletely rugulose, black, shining, having a yellow V, formed by the tip of the lateral margins. Hemelytra black or piceous, closely coated with yellowish pubescence; corium at base, with a pale yellowish, elongated spot, which runs along the suture and extends upon the clavus to behind the middle; there is also a vestige beyond the clavus, a small spot at the exterior tip and a large spot on the cuneus touching its base; membrane smoke-brown; the basal edge, nervures of the areole, and a paler spot on the middle also yellowish. Venter piceous, minutely pubescent; the superior genital appendages of the male yellowish, and the lateral appendage blackish. The deeply colored females usually have the venter black, more or less invaded by yellow or whitish spots on the middle and sides.

Length, 4 millimeters; width across the humeri, $1\frac{1}{4}$ millimeters.

This is a very common species in many parts of the United States. Specimens have passed through my hands which had been collected in Maine, Massachusetts, New York, New Jersey, Pennsylvania, Illinois, Michigan, &c. The present specimens were brought from Colorado. In Maryland the individuals are frequently to be seen upon the flowers of the ox-eye daisy. Upon being approached they suddenly run down beneath the calyx of the flower.

Agalliastes, Fieber.

A. associatus. New species.—General form of *A. pulicarius*, Fallen. Shining black. Head black, polished, impunctured; cranium indented on the middle; eyes brown, the orbits posteriorly yellow; antennæ stout, dull black; the second joint cylindrical, as thick as the basal one, about two-thirds as long as the third and fourth united; third and fourth almost equal in thickness, the latter shorter, tapering slenderly toward the tip. Rostrum yellow, reaching to the posterior coxæ. Pronotum transverse, moderately flat, polished, obsoletely rugulose, minutely punctured, transversely impressed near the front; the sides oblique, straight. Scutellum obsoletely, minutely scabrous, pubescent. Legs bright yellow. Hemelytra brownish black, with minute, yellowish, pubescence, obsoletely, coarsely punctured, and minutely scabrous; membrane smoke-brown, the nervule blackish; wings white. Abdomen black, with minute yellowish pubescence.

Length, 2 millimeters; width across the humeri, scarcely 1 millimeter.

Brought from Ogden, Utah, by the survey.

Family ARADIDÆ.

Aradus, Fab.

A. rectus, Say, (Heteropt., New Harmony, p. 29, No. 4.)—Obtained in Colorado. It inhabits also Missouri, Florida, New Mexico, British America, New England, &c.

Family PHYMATIDÆ.

Phymata, Latr.

P. erosa, Linn., (Systema Naturæ ed. xii, vol. II, p. 718, No. 19;) *Cimex scorpio*, De Geer, (Mémoires, III, p. 350, Pl. 35, Fig. 13.)—Brought from Colorado; but it is a common inhabitant of a great part of North America, extending south into Mexico and California.

Family REDUVIDÆ.

Nabis, Latr.

1. *N. inscriptus*, Kirby, (Fauna Boreali Amer., p. 280, No. 391.)—Inhabits Colorado, Indian Territory, &c., and is quite common in the Atlantic region.

2. *N. subcoleoptratus*, Kirby, (*ib.*, p. 282, No. 393.)—This is a common inhabitant of Colorado, Dakota, Canada, and the Northern States generally. Specimens occur fully winged.

Sinea, Amyot et Serv.

S. multispinosa, De Geer, (Mémoires, III, p. 348, Pl. 35, Fig. 11;) *Reduvius raptatorius*, Say, (Amer. Entom., Pl. 31.)—Brought from Colorado; but is an inhabitant of the greater part of North America, from Quebec in Canada to Southern Mexico.

Fitchia, Stål.

F. nigro-vittata, Stål., (Öfversigt af Kong. Vetens. Akad. Forhandl., 1866, p. 296.)—Collected in Cache Valley, Utah, and at Fort Cobb, In-

dian Territory. The apterous form has a conspicuous black vitta on the dorsal middle of the abdomen.

Diplodus, Amyot et Serv.

D. luridus, Stål., (Stettiner Entom. Zeitung, vol. 23, p. 452.)—Obtained in Colorado. It is a common species in the Atlantic region.

Pindus, Stål.

P. socius. New species.—Pale fusco-fulvous, or fulvo-testaceous, sparsely and slenderly pubescent. Form and aspect of *Diplodus luridus*, Stål. Upper side of head black; the upper cheeks, a slender line along the middle, a shorter one on the impressed line extending from the antennæ to the ocelli, a third broader line running from the middle of the eye posteriorly, and the under side of the head pale fulvous or testaceous; the tylus and a streak on the upper line of the lower cheeks blackish; the surface both above and below and the rostrum with minute, grayish pubescence; eyes brown; antennæ dull fulvous, fuscous on the upper side and at base and tip of the first two joints; the second joint about one-third the length of the basal one; third much stouter than the second, fully twice as long as it, tapering toward the tip. Rostrum reaching to the anterior coxæ, testaceous at base, becoming darker until finally piceous at tip. Pronotum clothed with dense, minute, hoary pubescence; the anterior lobe blackish, with its lateral carina pale fulvous; posterior and lateral margins of the posterior lobe yellowish-white; posterior angles each with a moderately short, smooth subconical, piceous tooth, and the carinæ each side terminated behind with a similar tooth; pectus and coxæ shining black; the sides usually with a broad, irregular, fulvous stripe along the middle and posterior pleuræ. Legs yellow, very hairy; all the femora a little tumid near the tip, sprinkled with fuscous; tip of tibiæ and whole of tarsi, including the nails, blackish piceous. Scutellum piceous, having a V-shaped elevation, which is rufous or yellow; the submargin broadly grooved; the margins and tip yellow. Hemelytra smoke-brown; the principal elevated nervures, costal margin, and cuneus pale testaceous; membrane pale brown, paler at tip; the nervules very dark brown. Tergum rufous, or rufo-flavous; the connexivum yellow, having blackish, subquadrate interruptions; the posterior segment margined behind with blackish; venter minutely scabrous, black, the middle line and sides broadly fulvous; its connexivum yellow, with a black, large spot at the apex of each segment.

Length to tip of abdomen, 10–12 millimeters; width across the humeri, 2–2½ millimeters.

Brought from the region of Snake River, Idaho. It inhabits also Kansas, Dakota, and Arizona.

Milyas, Stål.

M. cinctus, Fab., (Ent. Syst., IV, p. 199, No. 20.)—Collected at Cheyenne, June, 1869. It is tolerably common throughout the Atlantic and extends southwest into Texas.

Herega, Amyot et Serv.

H. spissipes, Say, (Jour. Acad. Phila., IV, p. 328; Amer. Entom., vol. II, Pl. 31, Fig. 3.)—Obtained in Colorado. This speceis seems to be

confined to western North America, no specimens having been discovered east of the Mississippi River.

Melanolestes, Stål.

1. *M. picipes*, H. Schf., (Wanz. Ins., vol. VIII, p. 62, Pl. 269, Fig. 831.)—Collected by Dr. E. Palmer, near Fort Cobb, Indian Territory; it has been found as far west as San Francisco, and is common in many parts of the Atlantic and Gulf States.

2. *M. abdominalis*, H. Schf., (Wanz. Ins., vol. VIII, p. 63, Pl. 269, Fig. 832.)—Found with the preceding. A specimen of this species has been sent to me from Southwestern Mexico.

Stenopoda, Lap.

S. cinerea, Laporte, (Essai sur les Hemiptères, p. 26, Pl. 52, Fig. 2.)—A pupa of this species was obtained by Dr. E. Palmer, near Fort Cobb. It is a species well known from Cuba, Texas, and Florida.

Family SALDÆ.

Salda, Fab.

1. *S. interstitialis*, Say, (Jour. Acad. Phila., IV, p. 324.)—Collected at Snake River, Idaho, and by Dr. Palmer at Fort Defiance, New Mexico. It extends east into New England, and along the Atlantic region into Maryland.

2. *S. coriacea*. New species.—General form of *S. littoralis*, Linn., of Europe. Black, polished; face densely, minutely shagreened, hairy; cranium minutely pubescent, faintly grooved on the middle; before the ocelli are two raised tubercles, placed remotely from each other; tylus and labrum yellowish; the rostrum piceous, reaching to the posterior coxæ. Eyes large, prominent, brown, placed very obliquely. Antennæ black, slender; the second joint sometimes pale piceous, more than twice as long as the basal one; the third and fourth subequal in length. Pronotum trapezoidal, the anterior side very much shorter than the basal; the lateral margins very oblique, hardly arcuated, the edge recurved; surface minutely shagreened, sparsely pubescent; the callosities obsolete, their locality faintly convex, with an indented, punctured, transverse line posteriorly; the posterior angles acute, with the margin behind the humeri very acutely oblique. Legs honey-yellow, or smoke-brown, usually darkened at the tip of tibæ and on the ends of the tarsal joints. Pectus highly polished, remotely, minutely pubescent, minutely wrinkled. Scutellum densely, minutely granulated. Hemelytra very convex, widest at some distance behind the middle, very considerably polished, remotely, coarsely, obsoletely punctured; the clavus bounded on the inner submargin and outer suture by an indented line of punctures; membrane coalescing with the corium, indistinctly piceous, sometimes with about three faintly yellowish spots between the long nervures. Venter brilliant black, closely, minutely punctured, coated with fine. sparse pubescence.

Length, 6–7 millimeters. Width across the humeri, 2 millimeters. Greatest width across the corium, 3½ millimeters.

Brought from Ogden, Utah. It is also found in New England, British America, and Illinois.

Family VELIIDÆ.

Macrovelia, Uhler.

General form of *Microvelia*, Westwood, but much more elongated. Head long and narrow, subconically narrowing toward the tip; the division before the eyes several times longer than that behind them; cranium arched, curving downward; the tylus short, forming a narrow, blunt carina at the anterior extremity. Antennæ slender, reaching beyond the tip of the scutellum; the basal joint stoutest, narrowed at base, a little curved; second a little shorter, stout, enlarged toward the tip; third and fourth very slender, subequal in length to the basal one. Eyes round, placed on the sides a little below the upper line of vertex and near the occiput. Ocelli in contact with the inner margin of the eyes. Rostrum very slender, reaching beyond the interior coxæ; the basal joint very short, ring-like; the second joint very long, about three times as long as the apical one. Thorax subcylindrical, widened behind, bilobate by reason of a transverse constriction before the middle; the anterior lobe with a tumid callosity each side; collum distinctly defined; humeral angles knob-like, posterior margin of pronotum scutellum-like, the tip bluntly rounded. Hemelytra narrower than the abdomen; the corium narrow, and with the membrane occupying also its inner margin. Legs long and slender.

M. Hornii. New species.—Fulvous, or reddish-brown, finely pubescent; the cranium bounded each side against the eyes by an impressed, oblique line, on the inner margin of which is a blunt, faintly elevated, oblique carina; the middle line slender, fuscous; cheeks and gular surface blackish; the space behind the eyes transversely tumid, the ridge joining inward to the slender carina, which runs along the whole length and forms a substitute for the bucculæ. Eyes dark brown. Antennæ yellowish-testaceous; the ends of the joints darker, and the two apical joints a little infuscated. Pronotum bright fulvous, coarsely, remotely punctured with fuscous, each side of the middle of the anterior lobe and disk, with a feebly elevated, longitudinal line; just behind the collum are two very slightly elevated, approximate tubercles; sides before the posterior lobe emarginated, the latero-posterior margins sinuated and the edge recurved. Pectus black, with the margins of the pleural segments fulvous. Legs pale yellow; the knees, tips, and a cloud upon the femora and the tarsi, dusky. Hemelytra in the fully winged, fuscous, silvery pubescent, with a large white spot at base, the costal margin and sometimes the inner margin of corium blackish; membrane paler near the tip. Connexivum pale, with a dark spot at the tip of each segment; venter pale fulvous, densely golden pubescent, the sides, superiorly, with a broad, blackish stripe not quite reaching to the tip. The short-winged form has the hemelytra dark brown, with a streak of white at base.

Length, 4–5 millimeters; width across the humeri, 1–1¼ millimeters.

Obtained at Fort Defiance, New Mexico. The species is named after Dr. George H. Horn, to whom I am indebted for specimens from California and Arizona.

Family HYDROMETRIDÆ.

Hygrotrechus, Stål.

H. remigis, Say, (Hemipt., New Harmony, p. 35, No. 2.)—Brought from Colorado, and Ross Fork, Idaho.

Limnotrechus, Stål.

L. marginatus, Say, (Hemipt., New Harmony, p. 36, No. 2.)—From Snake River, Idaho.

Family NAUCORIDÆ.

Ambrysus, Stål.

A. Signoreti, Stål., (Stettiner Entom. Zeitung, 1862, vol. XXIII, p. 460.)—From Red Butte and near Fort Fetterman. The specimens originally described were from Mexico. It is the most beautiful species thus far discovered in North America.

NOTES ON THE SALTATORIAL ORTHOPTERA OF THE ROCKY MOUNTAIN REGIONS.

BY PROFESSOR CYRUS THOMAS.

I.—SOURCES OF INFORMATION.

Having had the opportunity during the last three summers of traveling over much of the Rocky Mountain region, in connection with the United States Geological Survey of the Territories, conducted by Professor F. V. Hayden, I have been enabled to make large collections of *Orthoptera*. It is true that the opportunity for studying the habits of the various species has been limited, as we are constantly moving from point to point while in the field. Yet I have collected considerable information in regard to the distribution and the comparative numbers of the different species, especially of the two families of the saltatorial *Orthoptera*, to which my attention has been more particularly directed, *Locustidæ* and *Acrididæ*. During these three seasons I have visited the following Territories, to wit: New Mexico, Colorado, Wyoming, Utah, Idaho, and Montana, making collections in each.

In addition to my own collections I have had access to and free use of the collection made by Dr. Palmer in Northern Arizona, and to some collections in the Agricultural Department made by various persons in different parts of the West. I am also indebted to Mr. Taylor, of San Francisco, for some valuable California specimens, among which I found four new species. Mr. Charles R. Dodge, Assistant Entomologist of the Agricultural Department, who visited Nebraska, Colorado, and Kansas during the past summer, very kindly submitted his entire collection of *Orthoptera* to my use. From this I obtained several species which have not hitherto been described.

Several of my new species have been figured by Professor T. Glover, and will be found among the numerous plates of insects placed on exhibition in the museum of the Agricultural Department, where, also, the type specimens are deposited. I am indebted to Mr. S. I. Smith, of Connecticut, for a suit of New England *Acrididæ* for comparison; to Theophilus Rogan, esq., of Russelville, East Tennessee, for specimens of *Orthoptera* from that section, enabling me to verify some of De Haan's names; and also to Mr. J. Middleton, of Northwest Pennsylvania, for specimens from that mountain section.

I take great pleasure in acknowledging the many favors received from the Smithsonian Institution, and return thanks therefor, and also to Professor Baird and Dr. Gill for the valuable suggestions made in regard to my work.

II.—INTRODUCTORY REMARKS.

My study of the *Orthoptera* has not been sufficiently extended and thorough to enable me to form an arrangement of the various divisions and subdivisions that is wholly satisfactory to myself. Yet it is proper that I should at least indicate that system which I prefer, as it must to a greater or less degree determine the characters selected to distinguish the different groups, and the comparative value I attach to them.

Therefore, without attempting at this time to discuss fully the reasons therefor, I will state the order in which I believe the larger divisions should be arranged, and the leading principles upon which it is based.

Holding, as I do, the Cuvierian idea of four distinct types in the animal kingdom, as explained and unfolded by Agassiz, it is unnecessary for me to look further than the *Articulata* for the primary basis of an arrangement of a single order of insects. Within the limits of this group or "branch" are to be found all grades of development of the type, from its lowest and most obscure to its highest form, from the germ to the perfect animal. But the relations of the divisions of this group—that is, of the Annelides, Crustaceans, and Insects—to each other, must, to a certain extent, determine the arrangement of the divisions of these classes. The principles and reasons that cause us to place the Insects above the Crustaceans in the scale of being must, so far as they can be followed out, determine the position of the various divisions and subdivisions of the Insects in regard to each other.

While I cannot wholly agree with Dr. Packard as to the value he attaches to the different divisions of the *Articulata*, yet I prefer his arrangement of the orders* of the Hexapod Insects to any I have seen. This system, starting with *Neuroptera* as the lowest in the scale, ascends in two branches, one through the *Diptera* and *Lepidoptera* to the *Hymenoptera* as the highest in the class; the other through the *Orthoptera* and *Hemiptera* to the *Coleoptera*, but this last branch does not reach as high a point as that attained by the other. He places the *Orthoptera* not directly above the *Neuroptera* but sub-parallel to it. I believe that this arrangement gives the true position to the *Orthoptera*, for while this order, as a whole, stands higher than the other yet it is not absolutely above it. In other words, if I were an advocate of the Darwinian theory of the development of genera and species from lower forms, I would certainly hold that the *Orthoptera* were not developed from the *Neuroptera*, but that both orders arose from the *Myriapoda*, *Crustacea*, or some form of being lower than that found in the Hexapod Insects.

Although I am not a disciple of this great naturalist, yet I believe we may make use of the idea of development, which was advanced as early as the time of Lamark, to assist us in fixing the position of the various groups in the scale of being. As the highest form of a given type, (one of the four grand divisions of the animal kingdom,) in its passage from the germ to the adult state, assumes for a time the lower leading forms of that type, it follows that the various groups within that type stand exactly in the same relation to each other that they would if the higher

*I follow most entomologists, applying the name Order to the group he calls Sub-order, and Sub-class to the division he calls Order. See his Guide to the Study of Insects.

were absolutely developed from the lower. Therefore, while we should not rely upon this as our only guide in arranging the groups, yet it may be used to assist us.

While no system will fully accord with all the tests which can be applied to it, I think that of Dr. Packard comes nearer to it than any I have seen. But when we turn to his arrangement of the various families in *Orthoptera*, it appears to me he has somewhat abandoned the principles that guided him in fixing the position of the orders. I am aware that he has followed the system proposed by Mr. Scudder, which is founded on that of Burmeister, but it is evident that Mr. Scudder selected a somewhat different basis for his system from that adopted by Dr. Packard. Judging from the arrangement adopted by the latter in regard to the larger groups, I suppose he was guided more by the external form and mode of life than the former—not that he neglected the internal anatomy, embryology, &c.—but that the external anatomy, homologies and modes of life had more influence upon his arrangement than upon that of Mr. Scudder or Burmeister, whom the latter follows.

Although I have not studied all the families with that care and thoroughness that will enable me to speak with confidence, yet I am inclined to the opinion that the same principles and process of reasoning that led Dr. Packard to arrange the orders in the relative position in which he has placed them will reverse his arrangement of the families of the *Orthoptera*.

Fieber's arrangement,* if considered as descending, comes nearer to what I conceive to be the true plan than any other I have seen. It is as follows—

Tribe 1, Orthoptera genuina:	
Sec. I, Cursoria	Fam. 1, Blattina.
Sec. II, Gressoria	Fam. 2, Mantodea.
	Fam. 3, Phasmodea.
Sec. III, Saltatoria	Fam. 4, Acridiodea.
	Fam. 5, Locustina.
	Fam. 6, Gryllodea.
Sec. IV, Fossoria	Fam. 7, Gryllotalpina.
	Fam. 8, Xyodea.
Tribe II, Harmoptera	Fam. 9, Forficulina.

I think the division of the Crickets into three families can scarcely be maintained; I also think the *Locustina* and *Gryllodea* should be combined in a group as distinct from the *Acridiodea*. The proper position of the *Forficulidæ* is somewhat puzzling, for if we look at the external form and habits they would undoubtedly approach nearer to the *Blattidæ* than any other family; but if we take the internal anatomy as our guide, they descend to the foot of the order.

I would therefore arrange the various divisions in the following descending order, the position of the *Forficulidæ* being given with much doubt—

I. Sub-order Pseudo-orthoptera	Fam. 1, Forficulidæ.
II. Sub-order Orthoptera genuina:	
1. Tribe Cursoria	Fam. 2, Blattidæ.
2. Tribe Gressoria	Fam. 3, Mantidæ.
	Fam. 4, Phasmidæ.
3. Tribe Saltatoria:	
Sec. 1	Fam. 5, Acrididæ.
Sec. 2	Fam. 6, Locustidæ.
	Fam. 7, Gryllidæ.

* Kelch, Kennt. Orthop., Obers, 1852.

Mr. Scudder's arrangement appears to depend upon the position of the wings during the different stages of growth. As these organs in the *Saltatoria* change position during the different stages of growth, he considers this group as ranking higher than the others, in which they retain their primitive position. But does this correspond with the other important characters? With some it undoubtedly does, but with others it does not. Lacaze-Duthiers, who has studied with much care the genital organs of the various orders, states,* that if we take the development of the ovipositor as a guide, the divisions of this order will arrange themselves as follows: *Locustidæ, Gryllidæ, Mantidæ, Phasmidæ, Blattidæ, Acrididæ, Forficulidæ;* thus placing all the families of the non-saltatorial, genuine *Orthoptera* between the two sections of the *Saltatoria.*

Gerstaecker † brings the families of the saltatorial group together, but in a different order from that of Mr. Scudder, placing *Gryllodea* as the highest of this group, and next to *Phasmidea.*

If we examine carefully the elaborate researches of Léon Dufour, upon the Anatomy and Physiology of the *Orthoptera*, published in the *Mémoires de l'Institut* of France, vol. vii, 1841, we will see the difficulty of attempting to form an arrangement of the families based wholly on internal anatomy. The nervous system, digestive apparatus, genital organs, &c., will lead to different results. For example, if we take the nervous system as our guide, the result will be to place the *Acrididæ* at the head of the column, and, according to L. Dufour, the *Orthoptera* at the head of the class.‡ On the other hand, if we examine the digestive apparatus, we find the salivary glands of the same family the least developed of any in the order. And these contradictions are so well balanced that the preponderance is not sufficiently marked to form the basis of a system. There is perhaps one exception to this statement, to wit: if guided by internal anatomy alone we will, perhaps, be compelled to place the *Forficulidæ* as the lowest in the order; and it is quite possible that such is its proper position.

If we take the external form as our guide we cannot but be struck by the strong resemblance of the *Ceuthophili* and *Udeopsyllæ* to the crustacean form. And when we learn the habits of the former this resemblence assumes still more importance, as we find them along the margins of water-courses, and in the vicinity of damp places, hiding under stones in caves, and away from the rays of the sun.

I have often had my attention called to the general resemblance of the *Tridactyli* to the *Tettigi*, and the anatomical researches of Léon Dufour show this external similarity to be more than fancied, for he remarks: § "That the genus *Tetrix*, (*Tettix*,) founded by Latreille, appears to have been created by nature to serve as the connecting-link between the *Tridactyli* and *Acridii.*" If we trace the habits of these two groups, the suggestion of this author seems to be borne out by the result. The *Tridactyli* are found along the banks of streams and ponds; in fact, I have noticed myriads of them leaping on and off the surface of the water when the soft sand into which they had burrowed was disturbed.

At the next step from the moisture toward the dry localities we find the *Tettigi.* Find a spot where the summer sun has dried up a small pond of water and there you are apt to notice an abundance of specimens of both these groups; at least, this has been the case in that part

* Annales des Sci. Nat. Zool., tom. xvii, (1852,) p. 237.
† Carus, Handbuch der Zoologie, II.
‡ Mem. de l'Inst., vii, 282.
§ Op. cit., 315.

of the country where most of my examinations have been made. In the Rocky Mountain region, where there is but little moisture, and the land is elevated and dry, individuals of these genera are seldom to be met with. But I will not attempt to develop fully this thought at this time, as I have alluded to it more incidentally than otherwise.

The attempt to raise the smaller divisions to families, and to give them names with a termination indicating that they are family groups, has been carried to an extent that I think is wholly unwarranted by the distinctions. Family characters, until these groups were broken up of late years by the unnecessary inroads made upon them, were the best marked and most natural of any in the entire class. But how are they now? I cannot answer in regard to other orders, as my entomological studies have been confined almost exclusively to the saltatorial *Orthoptera;* but in this division of this order they are almost wholly worthless. For example, this group, which was formerly generally divided into but three, and never, I believe, into more than five families, is now separated by Walker* into twenty-one; and *Gryllidæ*, although as comprehensive as formerly, holds no higher position as a group than *Stenopelmatidæ*, *Oedipodidæ*, or even the single genus *Trigonopteryx.* By such an arrangement we are told, in effect, that there is less difference between *Gryllotalpa* and *Oecanthus*, or *Tridactylus* and *Phalangapsis*, than there is between *Thamnotrizon* and *Anabrus*, or *Opomola* and *Xiphocera.* Such a system is but adding confusion where there should be order, and renders that more difficult and complex which the increase in scientific knowledge ought to simplify and make plainer and more easily understood.

The family, as has been remarked by Burmeister,† "is peculiar to the natural system, and by this only is it called forth; Linnæus and Fabricius, who formed artificial classifications, had no families. The characters which distinguish the families are derived not only from their resemblances in structure in general, but also frequently from their economy." Agassiz‡ says, "Families, as they exist in nature, are based upon peculiarities of form as dependent upon structure." And he adds that they are determined by external outline, which renders the recognition of them easy, and in many instances almost instinctive.

If the rules laid down by these eminent naturalists are to be followed, where are we to find that striking difference in form between *Acridium alutaceum* and *Œdipoda Carolina* that will place them in different families, or even between *Acridium* and *Oedipoda*, that should cause them to be taken as the types of two different familes? What striking difference in external form is there between *Phylloptera* and *Platyphyllum*, as to separate them so widely that an entire family can be interposed between the groups to which they belong?

When the discovery of new species renders the family unwieldy, it can be divided or subdivided without destroying it, where it is well marked by true family characters. Therefore, while I shall to a greater or less extent retain the subdivisions that have been made, I shall assign to them such value as I think they really have, and shall not attempt to cut down or lessen the families. On the contrary, if I were to make any change, I would rather be disposed to unite the *Gryllidæ* and *Locustidæ* into one family.

I find there is considerable difference in regard to the use of the appellation "Tribe," sometimes being applied to groups superior to the

* Catalogue of the *Dermaptera Saltatoria*, Pt. V.

† Manual of Entomology, translated by Shuckard, p. 595.

‡ Methods of Study in Natural History, p. 111.

family, at others to those inferior to the family. I have followed the former method in the present report, but do this provisionally.

In regard to the terminology, I have only to remark that for families I adopt IDÆ; for sub-families, INÆ; and for the inferior groups, INI, thereby conforming to what appears to be the prevailing usage in other departments of zoology. I mention this, as by the termination I indicate the comparative value I attach to the group. In the *Locustidæ* I have adopted, for the present, the divisions of Walker, although I think his system defective; but I use them only as groups subordinate to sub-families and not as equivalents. The *Acrididæ* of the United States I am disposed to divide into but two sub-families, as follows:

I. Sub-fam. Acridinæ:
  First group, Truxalini.
  Second group, Conophorini.*
  Third group, Acridini.
  Fourth group, Œdipodini.
II. Sub-fam. Tettiginæ.

The number of species of saltatorial *Orthoptera* found in that part of the United States west of Iowa, Missouri, and Arkansas, which have been described, including the new species described for the first time in this report, is 101. These are distributed among the different families as follows: *Gryllidæ*, 7; *Locustidæ*, 33; *Acrididæ*, 61.

GRYLLIDÆ.

Gryllus	5 species.
Nemobius	1 species.
Oecanthus	1 species.

LOCUSTIDÆ.

First group, *Stenopelmatini.*

Stenopelmatus	3 species.

Second group, *Raphidophorini.*

Ceuthophilus	7 species.
Udeopsylla	1 species.
Daihinia	1 species.
Tropidischia	1 species.

Third group, *Bradyporini.*

Anabrus	4 species.

Fourth group, *Locustini.*

Pterolepis (?)	3 species.
Cyphoderris	1 species.
Thamnotrizon	1 species.
Decticus (?)	2 species.
Orchelimum	1 species.
Xiphidium	1 species.
Locusta	2 species.

*This name is used temporarily to embrace Mr. Scudder's sub-families, *Xiphoceredæ* and *Pœciloceridæ*.

Fifth group, *Conocephalini.*

Conocephalus	2 species.

Sixth group, *Phaneropterini.*

Phaneroptera	2 species.
Ephippitytha	1 species.

ACRIDIDÆ.

I. *Sub-family* ACRIDINÆ.

First group, *Truxalini.*

Opomola	4 species.

Third group, *Acridini.*

Acridium	3 species.
Caloptenus	10 species.
Pezotettix	5 species.

Fourth group, *Oedipodini.*

Brachypeplus	1 species.
Boopedon	2 species.
Stauronotus	1 species.
Œdipoda	26 species.
(Gryllus formosus)	1 species.
Acrolophitus	1 species.
Stenobothrus	6 species.
Oxycoryphus	1 species.

If we divide that part of the United States west of Missouri into three districts, as follows: the eastern, that portion east of the dividing range of the Rocky Mountains; the middle, that between the Rocky Mountain and Sierra Nevada Ranges; and the western, that west of Sierra Nevada, the following tables will show the distribution of the species described between these three districts:

EASTERN DISTRICT.

Gryllus personatus, Scudd.
abbreviatus, Serv.
Oecanthus niveus.
Nemobius vittatus.
Stenopelmatus fasciatus, Thos.
Ceuthophilus divergens, Scudd.
pallidus, Thos.
gracilipes, Scudd.
Udeopsylla robusta, Hald.
Daihinia brevipes, Hald.
Anabrus similis, Scudd.
purpurascens, Uhl.
Coloradus, Thos.
Pterolepis (?) Haldemannii, Gir.
Stevensonii, Thos.
minutus, Thos.
Thamnotrizon scabricollis, Thos.
Decticus (?) trilineatus, Thos.
Orchelimum ——— (?)
Xiphidium saltans, Scudd.
Conocephalus attenuatus, Scudd.
crepitans, Scudd.
Phaneroptera curvicadua.
Ephippitytha gracilipes, Thos.
Opomola brachyptera, Scudd.
bivittata, Serv.
Neo-mexicana, Thos.
Wyomingensis, Thos.
Acridinm emarginatum, Uhl.
frontalis, Thos.
ambiguum, Thos.
Caloptenus viridis, Thos.
bivittatus, Uhl.
Dodgei, Thos.

Calopetenus spretus, Uhl.
femur-rubrum, Burm.
occidentalis, Thos.
Turnbullii, Thos.
Pezotettix picta, Thos.
Nebrascensis, Thos.
speciosa, Scudd.
obesa, Thos.
Brachypeplus magnus, Gir.
Boopedon nubilum, Thos.
flavo-fasciatum, Thos.
Stauronotus Elliotti, Thos.
Œdipoda undulata, Thos.
collaris, Scudd.
cincta, Thos.
sordida, Burm.
longipennis, Thos.
Montana, Thos.
Wyomingiana, Thos.
gracilis, Thos.
Kiowa, Thos.
Œdipoda Haydenii, Thos.
tenebrosa, Scudd.
carlingiana, Thos.
Haldemannii, Scudd.
corallipes, Hald.
trifasciata, Say.
Carolina, Linn.
phœnicoptera, (?) Burm.
sulphurea, Burm.
neglecta, Thos.
Acrolophitus hirtipes, Thos.
(Gryllus) formosus, Say.
Stenobothrus curtipennis, Harr.
obionus, Thos.
maculipennis, Scudd.
brunneus, Thos.
quadrimaculatus, Thos.
bicolor, Thos.
gracilis, Scudd.
Oxycoryphus obscurus, Thos.

MIDDLE DISTRICT.

Gryllus abbreviatus, Serv.
luctuosus, Serv.
Oecanthus niveus, Serv.
Stenopelmatus fuscus, Hald.
fasciatus, Thos.
Udeopsylla robusta, Hald.
Anabrus simplex, Hald.
Decticus pallidipalpus, Thos.
Orchelimum ——— (?)
Ephippitytha gracilipes, Thos.
Locusta fuliginosa, Thos.
Phaneroptera ——— (?)
Opomola ——— (?)
Caloptenus bivittatus, Uhl.
Caloptenus spretus, Uhl.
occidentalis, Thos.
Pezotettix obesa, Thos.
Stauronotus Elliotti, (?) Thos.
Œdipoda corallipes, Thos.
Haldemannii, Scudd.
paradoxa, Thos.
trifasciata, Walk.
Carolina, Linn.
Montana, Thos.
cincta, Thos.
Stenobothrus maculipennis, Scudd.
brunneus, Thos.

WESTERN DISTRICT.

Gryllus Pennsylvanicus, Burm.
lineaticeps, Stal.
Stenopelmatus talpa, Burm.
Ceuthophilus castaneus, Thos.
pacificus, Thos.
bilobatus, Thos.
Californianus, Scudd.
zonarius, Walk.
Tropidiscia xanthostoma, Scudd.
Anabrus purpurascens, Uhl.
Cyphoderris monstrosa, Uhl.
Locusta occidentalis, Thos.
Caloptenus repletus, Walk.
bilituratus, Walk.
scriptus, Walk.
femur-rubrum, Burm.
Pezotettix Borckii, Stal.
Œdepoda atrox, Scudd.
venusta, Stal.
Carolina, Linn.
sulphurea, Burm.
phœnicoptera, Germ.
rugosa, (?) Scudd.
parviceps, Walk.

From these tables it will be seen that the following species are found in both the eastern and middle districts: *Gryllus abbreviatus*, *Oecanthus*

niveus, Stenopelmatus fasciatus, Udeopsylla robusta, Ephippitytha gracilipes, Caloptenus bivittatus, C. spretus, C. occidentalis, Pezotettix obesa, Œdipoda corallipes, Œ. Haldemannii, Œ. cincta, Œ. Montana, Œ. Carolina, Stauronotus Elliotti, Stenobothrus maculipennis, and St. brunneus.

Those found in both the middle and western districts are few, but it must be borne in mind that the collections in these two districts have been small, hence the means of comparison are very limited. I have given *Caloptenus femur-rubrum* and *Œdipoda rugosa* to the western district on the authority of Walker, but I have strong doubts as to the correctness of this.

The very great preponderance of the numbers in the eastern district is owing chiefly to the fact that the collections have been much larger and over a much greater area in this district than in either of the others. Another reason is, that I have limited to the eastern district those concerning which I have any doubt. My collections, and those to which I have had access, were not separated as accurately in regard to these districts as they should have been, hence I have placed them only in the districts to which I know they belong.

But notwithstanding this uncertainty as to the comparative numbers of species in the eastern and middle districts, yet it is evident the preponderance is strongly in favor of the former.

I think we may conclude with safety that the eastern limit of the arid plains which lie west of Iowa, Missouri, and Arkansas is a more rigid boundary to the orthopterous fauna than the dividing range of the Rocky Mountains; while on the western side the Sierra Nevada Range forms an equally rigid boundary. This corresponds with the distribution of the coleopterous fauna of the United States as shown by Dr. LeConte, (Smithsonian Contributions to Knowledge.)

I add the following notes in regard to the range of some of the more important species, which may be useful in future investigations:

Gryllus abbreviatus is found scattered over the plains at the base of the mountains from Southern Colorado to Central Wyoming. I also found specimens in Northern Utah, but when I reached the rim of the basin and passed into Southeast Idaho, entering the Snake River Basin, most of the specimens of *Gryllus* taken proved to belong to *G. luctuosus*.

Anabrus purpurascens is found, not abundantly, but at certain elevated points from Northern New Mexico to Montana, along the east base of the mountains, but I have met with no specimen west of the range in the middle district, though Mr. Uhler gives Washington Territory as a locality, on the authority of Dr. Suckley. It is also found as far south as Texas, and as far north as Red River, in Northern Minnesota. *A. simplex* appears to be confined to the middle district, as I have not met with it east of the range, and have seen no notice of it being found either in the eastern or western districts. Dr. Scudder, who examined the *Orthoptera* collected by Professor Hayden, in Nebraska, does not mention it in his list; nor did Mr. C. R. Dodge have it among his collections made in Nebraska, Colorado, Kansas, and Indian Territory; nor is it among the collections in the Agricultural Department made east of the Rocky Mountains. Hence I think we may safely conclude that it is confined to the west side of the range. But what it lacks in range is made up in numbers, for in the northern part of Salt Lake Basin and southern part of Idaho, the only points where I have met with it, it is to be seen in armies of myriads. But a fuller account of it will be found in the list.

Stenopelmatus fasciatus is found scattered sparsely over Wyoming, Northern Utah, and Southern Idaho, but does not appear to occur in

great numbers at any point. I have met with no specimens of *Ceuthophilus* in the middle district; yet I see no reason why they should not be found there; and Dr. Haldeman speaks (Stansbury's Report) of the larva of a *Phalangopsis* among the collections made in Salt Lake Valley.

Udeopsylla robusta is rarely met with, though it has a wide range. I do not think I have seen more than fifteen or twenty in the three summers I have traveled over the Western Territories. It is found from Western Kansas to Idaho, on each side of the dividing range.

Ephippitytha gracilipes appears to be a southern insect, as it has not been found farther north than Southern Colorado and Northern Arizona.

Opomola brachyptera has been observed in the adult state at only one point in the West, on the North Platte, east of the Black Hills; but I have some specimens in the larva state taken in Cache Valley, Utah, which, I think, belong to this species. *O. bivittata* does not appear to extend farther west than the broad plains of Kansas and Nebraska. When we approach the mountains in New Mexico and Colorado it is replaced by *O. neo-Mexicana*, a very closely allied species.

So far as I am aware, no species of *Acridium* has yet been traced to the immediate base of the mountains, the western range of the few species that extend upon the plains being confined to the extreme eastern part of Colorado and western part of Nebraska.

Caloptenus is represented in all parts of the West, as well as throughout the United States. (I cannot speak positively in regard to California.) *C. bivittatus* is found east of the range from New Mexico to Montana, and west of it from Salt Lake north to the head-waters of Snake River; and although it is not mentioned among the collections made in Washington Territory, yet I am of the opinion it will be found there. *C. spretus* is generally distributed from the Mississippi River to the Sierra Nevada Range, and north and south from Texas to British possessions. I have traced it west of the range in the middle district from Northern Arizona (I find it among Dr. Palmer's collections made there) to Helena and Deer Lodge, in Montana; but I have no satisfactory evidence of its being found in the western district. *C. Dodgei*, which is closely related to the *Pezotettigi*, has been collected only at a great elevation on Pike's Peak.

I have not met with *C. femur-rubrum* west of the mountains, and have some doubt in regard to most of the specimens found in Colorado and Wyoming which are referred to this species, for nearly all I have seen appear to have unspotted elytra, and to be uniformly more slender than the specimens found in the States. At one point in Wyoming I found these and *C. bivittatus* with the posterior tibia invariably of a bluish-purple color, yet when immersed in strong alcohol they became of a bright purplish-red before the color entirely faded.

Pezotettix picta, which is a very pretty insect when living, looking very much like the larva of *Romalea centurio*, appears to be confined to Eastern Colorado. *P. obesa* has been found only on the mountains, between Southern Montana and Idaho, at an elevation of more than six thousand feet.

The range of the species of *Œdipodini* will be given in my synopsis, as I have not yet completed the examination of all my specimens of this group.

The relative numbers of species in the various groups correspond with what might be anticipated from the character of the country. Where broad and comparatively barren plains occupy a large portion of the area of the country, it is natural that the *Calopteni* and *Œdipodini* should predominate, and that the *Locustidæ* should be less numerous

than the *Acrididæ*. Not only does *Acrididæ* contain nearly twice as many species as *Locustidæ*, but the number of individuals of the former is, if we omit the single species *Anabrus simplex*, infinitely greater than the latter.

In Mr. Scudder's Materials for a Monograph, he mentions 41 species of *Locustidæ*, and but 38 of *Acrididæ*, exclusive of *Tettiginæ;* Serville, in his Hist. Nat. Orthopteres, describes 142 species of the former, and 172 of the latter; and Walker, (Cat. Dermap. Salt. Orthop.,) exclusive of the *Tettiginæ* and additions in Part V, enumerates 910 species of the former and 921 of the latter. These show that, as a rule, the two families contain nearly the same number of species. But, while this appears to be the general rule, in the West there are 60 species of *Acrididæ* to 34 of *Locustidæ*.

Although the number of individuals of one of the species of *Acridini* is far in excess of the number of individuals of any species of *Œdipodini*, yet a glance at the tables will show that the number of species belonging to the latter group is much larger than that of the former, *Œdipoda* alone containing 24 species. And while in the eastern and middle districts *Caloptenus spretus* only is migratory, when we cross into the western district *Œdipoda atrox* is the destructive migratory species, indicating an approach to the oriental orthopteral characteristic.

An examination into the different species of the *Locustidæ* brings out another important fact corresponding with the nature of the regions under consideration. Out of 34 species 23 are either wingless or have these organs so aborted that they are unfit for flight, indicating most clearly the absence of arborescent vegetation, and the prevalence of extensive treeless plains. The number of *Ceuthophili* is larger than I had expected to find it, as, upon the theory I have adopted, these affect damp places, and are confined more to the margins of water-courses, lakes, &c.; but the fact that the species are confined to the eastern and western districts somewhat conforms to this idea.

III.—A LIST WITH DESCRIPTIONS OF NEW SPECIES.

FAMILY I.—GRYLLIDÆ.

Gryllus abbreviatus, Serv.

Found throughout Colorado, in Wyoming, and occasionally in Northern Utah and Southern Idaho. Specimens generally large, the length of the ovipositor exceeding the measurements given by Mr. Scudder.

G. luctuosus, Serv.

I met with this species in the extreme northern part of Utah, and in Southern Idaho, where it appears to replace the former species. Size larger than the usual measurements, and ovipositor longer, yet I feel no doubt that the specimens referred to this species belong to it. Plate I, Figures 10 and 11.

Oecanthus niveus, Serv.

I am not positively certain that my specimens belong to this species, as most of them are more or less injured. It occurs in considerable numbers along the banks of streams lined with bushes.

Tridactylus, ——.(?)

I saw what I am quite confident was a specimen of this genus on the bank of Bear River in Cache Valley, Utah, but was unable to capture

it. This is the only instance I recollect to have met with an individual of this genus in any of the Territories, and possibly I may have been mistaken here, but I think I was not.

LOCUSTIDÆ.

STENOPELMATINI.

Stenopelmatus fasciatus, nov. sp.

Pale testaceous. Head tawny; feet pale; abdomen marked with alternate rings of black and white.

Head slightly broader than the thorax; occiput evenly rounded and smooth. Pronotum transverse, slightly excavated in front; sides nearly parallel; posterior lateral angles obtusely rounded; posterior margin nearly straight; a transverse furrow near the anterior margin, and an oblique indentation each side of the faint median line near the middle. Meso- and meta-thorax constricted. Abdomen inflated, as broad or broader than the head, about twice the length of the thorax. Cerci of the male short, slender, and hairy; superanal plate triangular, tumid, emarginate. Ovipositor very short, not longer than the cerci of the male, conical and turned up at the apex. Anterior tibiæ two-spined beneath, with a third small spine immediately above the circlet on the inner margin; middle tibiæ with two spines on the outer margin, one on the inner, and a small one in the middle near the base; posterior tibiæ in the female have five inner and three outer spines, in the male five inner and four outer. Both sexes apterous.

Color, (after immersion in alcohol, but varying very slightly from the living specimens:)

Female.—Mandibles black; face yellow; head brownish or tawny; pronotum tawny, fading to light yellow; legs, venter, and sternum pale yellow; spines tipped with piceous. Each abdominal segment has a broad ring or band of black on the anterior or middle portion, and a narrow band of pale yellow on the posterior margin; sometimes the latter extends across the suture upon the margin of the next segment.

Male.—Mandibles tipped with black; labrum fuscous; head and thorax paler than in the female; apex of the tibiæ dusky. Dark bands of the abdomen grow narrower on the apical segments.

Dimensions.—♀ ♂, length, 1.23 inches; posterior femora, .38 inch; posterior tibiæ, .37 inch. I have a specimen from Texas, a female, which measures 1.65 inches in length, but the above measurements give the average of the western specimens.

Habitat.—Wyoming, Utah, Southern Idaho, and Texas. Rare, never being found in great numbers at any point.

This species, though not exactly agreeing with Group II of Walker, (Cat. Dermap. Salt., Supp. to pt. I, p. 197,) is closely allied to his *S. zonatus.*

RAPHIDOPHORINI.

Ceuthophilus pallidus, nov. sp.

Pale testaceous; with four strong spines on each superior margin of the posterior tibiæ.

Female.—Second joint of the antennæ enlarged at the apex; anterior femora with two (sometimes three) spines beneath, near the apex, the one next the apex being much the largest; middle femora with one or two spines beneath, and one on the inside of the apex; posterior femora unarmed; the four anterior tibiæ generally have two spines in

each row; the posterior tibiæ with each superior margin minutely serrated and furnished with four strong spines in each row, somewhat divergent and alternate, (though in many specimens they appear to be sub-opposite,) the inner row extending farthest upward toward the base; ovipositor nearly straight, about as long as the abdomen; cerci slender, hairy, one-third the length of the ovipositor; posterior femora extend nearly one-half their length beyond the abdomen.

Male.—The posterior femora armed beneath with a row of strong spines on the exterior carina, the inner carina being finely serrated; cerci similar to those of the female but rather longer; ultimate ventral segment tumid and bilobed.

Color, (alcoholic specimens, scarcely differing in color from the living).—Pale testaceous; face and labrum pale, lightest in the male; vertex and occiput, in the female, minutely dotted with brown, in the male, with narrow, branching, dusky veins; tubercle fuscous; eyes black, acuminate below; each thoracic and abdominal segment has on it four somewhat irregular brown spots, those on the thorax running together on the disk, and those on the abdomen growing smaller toward the apex; the position of these spots leaves a pale line along the dorsum and on each side; posterior femora marked with slender, brown lines diagonally across the disk, and two longitudinal dashes of the same near the lower margin; spines of the tibiæ white with piceous points; serrature of the posterior tibiæ piceous; venter and pectus white, or pale testaceous.

Dimensions.—♀, length, .54 inch; posterior femora, .47 inch; posterior tibiæ, .51 inch; ♂, length .5 inch.

Habitat.—Southeast Colorado; and east side of Black Hills, near Red Buttes, Wyoming.

I at first referred these specimens to *C. divergens*, Scudd., and it is possible they form but a variety of that species, with which they agree in several particulars. While some of my female specimens have divergent spines, this character is by no means permanent, especially in the males. The *C. divergens* has five spines in each row on the posterior tibiæ, but my specimens, males and females, have but four, (I take for granted that none of the circlet at the apex are counted.) This species approaches very nearly to *C. zonarius*, Walk., but may be distinguished by the difference in the number of spines on the middle femora and middle tibiæ.

C. castaneus, nov. sp.

Male.—Dorsum, castaneus; middle tibiæ with two spines in front; posterior tibiæ with four spines in each row, opposite. Maxillary palpi long; third joint about twice the length of the two preceding taken together, slightly bent, obliquely truncate; fourth three-fourths the length of the third; fifth a little longer than the third, curved and channeled as usual. Frontal tubercle nearly obliterated. Eyes sub-pyriform, not prominent. Antennæ apparently of moderate length, (those of my unique specimen have the apical portion broken off;) they have a broad, dish-like fold around the base; first joint flattened, very broad, length slightly exceeding the width; second, length equal its diameter; third, twice the length of the second; from the middle to the end every tenth or twelfth joint is constricted, forming a pale-yellow annulation. Thoracic segments slightly margined. Cerci rather long and slender, about one-third the length of the abdomen, covered with minute hairs. Subanal plate abnormal, extending back more than half the length of the cerci, triangular and bilobed, the lobes blunt at the apex, having

much the appearance of a short, blunt ovipositor. Legs more than medium length; anterior and middle pair slender. Anterior femora serrated, inner carina one-spined, outer carina unarmed; middle femora with each carina minutely serrated and three-spined, and a spine on the inside at the apex; posterior femora deeply channeled beneath, each carina minutely serrated but not spined, passing the abdomen about one-half their length. Anterior tibiæ have the posterior margins minutely serrated, three spines on each, opposite; middle tibiæ with two spines above, lower margins serrated, three spines on each, opposite; posterior tibiæ have the posterior margins serrated, four spines on each, opposite; four teeth of the serrature between the spines. Anterior coxæ mucronate on the exterior angle.

Color, (dry, not alcoholic.)—Face pale yellow; upper portions of the head tawny. The entire dorsum pale castaneous, with somewhat darker bands on the posterior margin of each segment, scarcely distinguishable. A slight median yellow line on the thorax. Legs dull yellow, the posterior pair darkest; spines yellow, not tipped with black; eyes black; antennæ fulvous.

Dimensions.—Length, .70 inch; posterior femora, .5 inch; posterior tibiæ, .5 inch. California. Presented by Mr. Taylor.

This may possibly be the male of Dr. Scudder's *C. Californianus*, but the great difference in the length of the posterior femora would seem to forbid this conclusion, although the color and absence of spines on the posterior femora indicate a similarity. My specimen is evidently much larger than the one he describes. This species appears to form a connecting link between *Ceuthophilus* and *Udeopsylla*, the head and thorax having a strong resemblance to the latter genus.

C. pacificus, nov. sp.

Male.—Golden yellow, dotted and minutely mottled with fuscous; posterior femora with one large serrated spine on each carina; middle tibiæ spined above.

Tubercle of the vertex prominent, pointed. Ultimate joint of the maxillary palpi unusually long, bent, and somewhat angled behind near the base. Circi rather large, acuminate. Tip of the last ventral segment notched, and furnished on the outside of each lobe with a short fusiform appendage. Anterior femora one-spined, not serrated; middle femora one or two spined, not serrated. Posterior femora much enlarged for the basal three-fourths, suddenly contracted beneath near the apex; a broad and tolerably deep sulcus beneath; each margin minutely serrated part of its length and furnished with one strong and very broad spine. Each of these spines is serrated on the anterior margin; the one on the interior margin is the largest and stands farthest from the apex; between these spines and the apex the margins curve upward, forming a kind of circular notch, and corresponding to this is an enlargement or swelling of the front of the posterior tibiæ near the base. The posterior femora are scabrous on the disk and upper edge. The middle tibiæ, in addition to the usual spines below, are furnished on the upper face with four spines, two in a row; posterior tibiæ serrated, four spines on each posterior margin, opposite.

Color, (dry, but not alcoholic.)—Ground color of the dorsal portions golden yellow; of ventral surface and legs, a honey yellow; the face mottled with fuscous, forming three irregular spots, one beneath each eye and one in front; vertex and tubercle black; cranium with a few slender black lines, mostly longitudinal. The entire dorsum sprinkled over with small irregular fuscous dots, giving it a mossy appearance.

Segments 2–8 have on each, near the posterior margin, a single row of white dots. Posterior femora marked on the upper part of the disk with oblique, brown, scabrous lines; along the middle of the disk runs a slight sulcus, which is bordered by a stripe of brownish scabrous points; there is also another short stripe of the same, each side of the sulcus, near the apex. Posterior tibiæ striped with brown in front.

Dimensions.—Length, .5 inch; posterior femora, .43 inch; posterior tibiæ, .43 inch. From California. Presented by Mr. Taylor.

C. bilobatus, nov. sp.

Male.—Femora unarmed. Posterior tibiæ multispined; spines alternately long and short. Frontal tubercle bilobed. Venter bright yellow; ultimate segment with a black fascia.

Frontal tubercle deeply bilobed; a transverse impression immediately below it; eyes round, not docked on the inside; third joint of the antennæ not longer than the second. Abdomen faintly keeled on the posterior segments; superanal plate (or last abdominal segment) deeply bilobed; the short cerci protruding from beneath it by the lateral margins of the lobes at a circular notch; ultimate ventral segment notched at the tip, and longitudinally sulcate beneath. Femora neither spined nor serrated. Anterior and middle tibiæ, although quite hairy, do not appear to be spined or serrated; posterior tibiæ not serrated but spined on the posterior margins nearly their entire length, spines nearly opposite, alternately long and short in each row; first joint of the posterior tarsi with a strong curved spine above at the apex. All the tibiæ appear to be square, having four nearly equal flat faces.

Color, (dry, but not alcoholic.)—General and nearly uniform color an ash-brown, with numerous orange-yellow dots. Tips of the mandibles piceous black; a narrow, black, transverse line immediately below the frontal tubercle; eyes brown. Two oblique, short, black stripes on the meso- and meta-notum, diverging posteriorly, one each side reaching across the two segments, bordered above, especially on the metanotum, with an orange-yellow stripe. Venter a bright yellow, the ultimate segment, with a black band across the middle, expanding at the lateral margins.

Dimensions.—Length, .45 inch; posterior femora, .28 inch; posterior tibiæ, .26 inch. California. Presented by Mr. Taylor.

I had a specimen of what I am satisfied was the female of this species, but, unfortunately, it was destroyed before a description of it was taken. All I can state positively in regard to it is, that the ovipositor was very short, strongly curved upward, falcate. Color more of an ash-gray than the male; the stripes on the thorax very distinct. About the same size as the male.

The characters of this species will probably require the formation of a new genus for its reception, but the general appearance is sufficiently near the typical *Ceuthophili* to place it at once in that group; therefore, rather than multiply generic names, I place it here for the present, but have given a full description, that the generic characters may be known.

Udeopsylla robusta, Scudd.

Syn., *Phalangopsis* (*Daihinia*) *robusta*, Hald.

I have found this species at a few points in Wyoming, Colorado, Utah, and Southern Idaho. It appears to be generally distributed on the plains and open sections of the Rocky-Mountain regions, but not abundantly. I have seen very few females. Although the "upper

surface of the femora is sparsely scabrous," I have not noticed this to be the case with the "dorsum," as stated by Haldeman.

BRADYPORINI.

Anabrus simplex, Hald.

Found in great abundance between Brigham City, Utah, and Fort Hall, Idaho. Also occasionally met with farther south in Utah and north of Fort Hall to the boundary line of Montana, which is here along the range separating the waters of the Atlantic from the Pacific. At some points we found them so abundant as literally to cover the ground. In two or three instances they all appeared to be moving in one direction, as if impelled by some common motive. I recollect one instance on Port Neuf River, where an army was crossing the road; it was probably as much as two hundred yards in width; I could form no idea as to its length; I only know that as far as I could distinguish objects of this size, (being horseback,) I could see them marching on. I think that in all the cases where I saw them thus moving, it was toward a stream of water. They appear to be very fond of gathering along the banks and in the vicinity of streams. In the north part of Cache Valley I frequently noticed the ditches and little streams covered with these insects, which, having fallen in, were floating down on the surface of the water, and, though watching them for hours, they would flow on in an undiminished stream.

While encamped on a little creek near Franklin, in this valley, it was with difficulty we could keep them out of our bedding; and when we went to breakfast we found the under side and legs of the table and stools covered with them, all the vigilance of the cook being required to keep them out of the victuals.

But the strangest part of its history is that it will go in pursuit of and catch and eat the *Cicada*. This latter insect also made its appearance in this valley the past season in immense numbers, covering the grass and sage and other bushes, especially those which formed a fringe along the little streams. Up these the *Anabrus* would cautiously climb, reach out with its fore leg and plant its claw in its victim's wing; once the fatal claw secured a hold, the *Cicada* was doomed, for without ceremony it was at once sacrificed to the voracious appetite of its captor. No uniformity appeared to be preserved in this process; sometimes they would commence with the thorax, at others with the head, not even taking the trouble to remove the legs or wings.

I noticed in the road, where one of the armies was crossing, a number of large hawks feasting themselves upon the helpless victims. As I returned through Malade Valley, (August 20, 1871,) the females were depositing their eggs. They press the ovipositor perpendicularly into the ground almost its entire length. Pl. I, fig. 1.

A. purpurascens, Uhler.

Syn., *Thamnotrizon pupurascens*, Thos.

I have found no specimens of this species west of the Rocky Mountain; yet it may possibly be found on the higher plateaus.

In my paper (Proc. Acad. Nat. Sci. Phila., 1870, p. 76, and Rep. U. S. Geol. Surv. Wyom. Ter., 1870, p. 268) I removed this species from *Anabrus* to *Thamnotrizon*, because the prosternum is unarmed. I did this because *A. Haldemannii*, Girard, of which I had several specimens, has the prosternum distinctly spined, and in other respects differs from the

purpurascens. I had not then seen a specimen of *A. simplex*, Hald.; nor had I seen the excellent synopsis of the European species of *Thamnotrizon* by Brunner de Wattenwyl, (in Verhandl. Zool.-Bot. Vereins in Wien, XI, 1861,) the articles by Yersin, (Ann. Soc. Ent. Franc., 3d ser., Tom. VI and VII,) or Fieber's Synopsis, (Lotos, 1853.) Now, having specimens of all the species (*simplex*, *Haldemannii*, *purpurascens*) before me, and access to the works named and those of Serville, Fischer, &c., I find that while I was correct in separating the species, I was mistaken in the disposition made of them, and, as a matter of course, in my emendation of the generic characters.

The genus *Anabrus* was formed by Haldeman for the reception of his *A. simplex*, hence in emending the original description its characters should be such as to embrace the species on which it was founded. A more thorough examination of the generic characters of *Thamnotrizon* as given by the various authors; a comparison of the figures by Brunner de Wattenwyl, Von Frauenfeld, Fischer, &c., and personal inspection of some specimens which I am satisfied belong to this genus, discovered the past season, lead me to the conclusion that the arrangement and number of spines on the front of the anterior tibiæ is a true normal character, although having some slight exceptions, (for *T. fallax* appears from the figure in Verhandl. Zool.-Bot., XI, 1861, Pl. 10, to vary from this type.) As *A. simplex* and *purpurascens* have two rows of spines on the front of the anterior tibiæ, (one 4–5, the other 2–3, making in all 6–8,) they cannot belong to this genus, but should remain where originally placed. *A. Haldemannii*, having the prosternum very distinctly bispinose, must be placed in some other genus, and even without this distinction there are other differences which will remove it from generic association with these species. I am not well satisfied where it should go, but place it provisionally in *Pterolepis*, Fisch., (not Serville,) with which it appears to be most nearly allied.

There is much confusion in regard to this group of genera. Fischer (Orthop. Europ.) separates *Thamnotrizon* from *Pterolepis* of Rambur, placing the species without prosternal spines in the former, leaving those with spines in the latter; while Serville places the species without prosternal spines in *Pterolepis*. Fieber, following Serville, places the unarmed species in *Pterolepis* and forms a new genus—*Rhacocleis*—for those which are spined. Yersin (Ann. Soc. Ent. Franc., 3d ser., VI) describing *Pterolepis alpina* gives the spines as a character. *Orchesticus* of Saussure (Rev. Mag. Zool., 2d ser., XI., 1859, p. 201) comes very close to this, the chief difference being in the mesosternum. Brunner de Wattenwyl appears to follow Fischer in regard to *Thamnotrizon*, but on the other hand adopts the *Rhacocleis* of Fieber for his spined species, omitting *Pterolepis* altogether. He forms a sub-genus in *Decticus*, which he names *Psorodonotus*, to which he removes *Pterolepis alpina*, Yersin.

In the midst of such confusion, which Walker has increased by the formation of several too closely-allied genera, it is difficult to place a somewhat abnormal species. It is probable Dr. Scudder will clear up this difficulty in his anxiously looked-for work on the *Orthoptera*; therefore for the present I have adopted the following arrangement as the best I can do with the materials I have at hand. I would not venture to take this step if it were not necessary to adopt some consistent arrangement of the new species I obtained during my recent visits to the Rocky Mountains.

Discarding *Rhacocleis*, Fieb.; retaining *Pterolepis*, Fisch., (Not. Serv.;) and restricting the other genera to their true limits, the genus *Anabrus*

will stand as distinct, and its relation to the others may be represented as follows:

A. Anterior tibiæ spined in front:
  a. Prosternum spined. (*Thyreonotus, Pterolepis = Rhacocleis, Orchesticus.*)
  aa. Prosternum not spined:
    b. Pronotum distinctly carined; anterior tibiæ with three or four spines in front .... *Decticus*, (prop.)
    bb. Pronotum with sub-distinct lateral carinæ; anterior tibiæ with three spines in front; elytra not squamæform. Sub-genus .... *Platacleis.*
    bbb. Pronotum without distinct lateral carinæ; elytra squamæform:
      c. Anterior tibiæ with but three or four spines in front; one row .... *Thamnotrizon.*
      cc. Anterior tibiæ with six or eight spines in front; two rows .... *Anabrus.*

This is rather artificial, depending too much upon a minor character, but will perhaps accord with a more thorough and natural arrangement when made. I have slightly expanded Fischer's spine character of *Decticus.* I am aware that *Thamnotrizon* and *Anabrus* have been placed in different groups, and although I follow the arrangement in this article, I confess I think the differences scarcely warrant the separation.

A. coloradus, nov. sp.

Rather smaller than *A. simplex* or *A. purpurascens;* ovipositor shorter and more curved upward. Abdomen with brown bands.

Eyes small, round, the most angular portion being below. Pronotum rrather short; posterior part sub-tricarinate, somewhat flattened; apex truncate. Abdomen decticoid. Superanal plate of the female round; subanal plate sub-quadrate, tumid, with a short spine at each apical angle, and a short, broad spine each side of the base. Prosternum not spined; meso- and metasternum, with the lateral angles elevated, acute. Superanal plate of the male somewhat acute-angled; cerci with the two prongs, mucronate, the lower ones strongly curved inward; subanal plate deeply notched; cylindrical appendages short. Legs slender, short; posterior femora with three or four minute abortive spines on the lower exterior carina.

Color, (dried after immersion in alcohol.)—Dull yellow, varied with brown. Face yellow; occiput of the female brown; male pale. Disk of the pronotum brownish, posterior portion dark; lower margins of the sides yellow. Each abdominal segment with a brown band on the base. Venter and pectus dull yellow. Elytra and wings as usual, abortive.

Dimensions.—♀, length, 1.28 inches; pronotum, .38 inch; posterior femora, .68 inch; posterior tibiæ, .70 inch; ovipositor, .73 inch. ♂, length, 1.12 inches. Eastern Colorado.

LOCUSTINI.*

* I follow Walker in giving this division, but I reduce it to a group, yet it does not accord with my opinion as to the boundary-lines, for I really believe *Thamnotrizon* should be placed in the same group as *Bradyporus.* But as I have not studied the species of this family with sufficient care to give a satisfactory outline of the divisions, I follow those of other authors.

Thamnotrizon scabricollis, nov. sp.

Pronotum roughly punctured, dark purplish. Femora striped with yellow.

Female.—Head smooth; first joint of the antennæ broad, flattened; frontal tubercle broad, flat, and truncated below by the transverse sulcus between the antennæ. Pronotum of moderate length, sub-tricarinate, expanding posteriorly; deeply and coarsely punctured, so as to render it somewhat scabrous; a distinct, oblique impression each side of the median carina; a smooth space on each side near the middle; lateral carinæ obtuse, truncate in front, obtusely rounded behind; sides extend lowest at the anterior coxæ, angles rounded, posterior oblique; margin slightly curved inward. Abdomen large, nearly twice as long as the thorax, carinated; apex of the last segment suddenly narrowed, forming a slight entering angle each side; terminal, triangular portion somewhat tumid and excavated at the middle of the upper surface. Cerci very small, pointed. Subanal plate very large and broad, with a square notch at the middle of the apex; ovipositor slightly curved, acuminate. Elytra extend the width of one segment beyond the pronotum. Femora all unarmed. Anterior tibiæ, with one row, 3–4 spines above, situate somewhat on the external face; middle tibiæ with two rows above, inner row 5–6 spines, outer 4; posterior tibiæ with two rows beneath. Posterior femora slightly arcuate near the base, about as long as the abdomen; appendages to the first dorsal joint about as long as the apical spines, sub-reniform.

Color, (after immersion in alcohol, but very near as when living.)—Face yellow below the eyes; two brown dots on the clypeus; buccal suture fuscous; base of the antennæ yellowish, a purple dot on the front of the first joint; occiput purple. Pronotum brownish-purple, palest near the apex; broadly margined on the sides with yellow. Abdomen dark-purple, with paler points and spots; ovipositor testaceous, fuscous at the apex and along the upper edge. Posterior and middle femora light-purple, with rows of black dots along the disk. Tibiæ purplish, spines piceous at the tips. Elytra, which are very small, have a purple disk and yellow margin.

Male.—Cerci short, very robust, with an obtuse inner tooth at the apex; subanal plate large, elongate, deeply notched at the apex, the notch forming an acute angle; the cylindrical appendage at the tip of each lobe, short. Elytra, extending across two segments, colored, as in the female.

Dimensions.—♀ ♂, length, 1.25 inches; posterior femora, .75 inch; posterior tibiæ, .74 inch; ovipositor, .77 inch.

Found in Southern Montana on the dividing range of the Rocky Mountains at an elevation of 6,000 to 8,000 feet above the level of the sea.

Pterolepis (?) *Haldemannii*, Thos.

Syn., *Anabrus Haldemannii*, Girard.

I have met with this species only in Colorado and Eastern Wyoming. I am rather inclined to think it does not belong to the Pacific slope.

P. (?) *Stevensonii*, Thos.

Syn., *Anabrus Stevensonii*, Thos.

P. (?) *minutus*, Thos.

Syn., *Anabrus minutus*, Thos. (Pl. II, Fig. 17.)

For the reasons heretofore given, these species will also have to be

removed from *Anabrus*, and I place them in this genus with some hesitancy. Nor can I decide the point satisfactorily without a better knowledge of these genera. I have not met with either of these species on the western slope.

Decticus pallidipalpus, nov. sp.

Female.—Face round, smooth; occiput convex, smooth, terminating at the vertex in an oblique cone, separated from the face by a cross impression between the antennæ. Antennæ longer than the body; first joint broad and flat, not reaching the top of the vertex; third joint cylindrical, about twice as long as the second; rest of the joints have on them a few scattering hairs. Maxillary palpi less than twice as long as the labial; fifth joint longest, sub-clavate, with rounded apex, straight; third joint a little longer than the fourth, which is slightly curved. Labrum obovate, wide as the clypeus; the latter subtriangular, not separated from the face. Pronotum short, but not transverse, having three distinct and equal carinæ, the lateral slightly converging a little in front of the middle; front margin truncate, slightly waving; posterior margin obtusely rounded; lateral margin extends below the lower border of the eyes, the lowest part a little behind the anterior angle, the angles rounded; the posterior, oblique lateral margin slightly curved inward; no cross incisions, the carinæ being continuous. Elytra and wings hid by the pronotum. Abdomen convex above, about twice the length of the thorax; ovipositor about as long as the abdomen, straight, pointed at the apex; the last ventral segment triangular, deeply notched at the apex, notch square; superanal plate triangular, entire; cerci minute. Prosternum not spined or tuberculate, transverse; meso- and meta-sternal angles elevated into triangular plates, but not spined. Posterior femora very slightly spined beneath; other femora unarmed. Anterior tibiæ with one row of three spines in front, on the external margin; middle tibiæ with two rows above, four on the outer and two on the inner margin; posterior tibiæ with two rows of fine spines below; the appendages to the base of the first joint of the tarsi oblong.

Color, (after immersion in alcohol.)—Pale, dull yellow, somewhat uniform, the dorsal portions generally a little the darkest and sometimes with a reddish-brown tinge. Legs tinged with dull purple, or testaceous. Antennæ pale at base, rest fuscous; eyes brown, with sanguinous spots on the inner side, one or two of a similar character at the front of the base of the antennæ.

Male.—Elytra project from beneath the pronotum in the form of scales, crossing one or two segments; disk brown; margins yellow. Apex of the last abdominal segment notched; cerci robust, curved inward, a strong bent tooth on the inside about the middle; tip of the last ventral segment notched, appendages blunt. Dorsal portions and legs pale purplish.

Dimensions.—♀, length, 1 inch; ovipositor, .74 inch; posterior femora, .81 inch; posterior tibiæ, .73 inch. ♂, length, .87 inch; posterior femora, .73 inch; posterior tibiæ, .69 inch.

Found at Copenhagen, Utah; mouth of Port Neuf River; and on Snake River, Southern Idaho. June 15–25.

I think that when living the general color is a pale pea-green.

This species is closely allied to the section established by Walker, (Cat. Dermap. Salt., pt. II, 259,) the following slight variations being noticed: the difference in the number of tibial spines; no longitudinal furrow between the eyes, except in dried specimens; the two oblique

furrows of the face seen only in dried specimens, the face being regularly convex.

D. trilineatus, Thos.

Syn., *Thamnotrizon trillineatus*, Thos.

This species probably belongs here, as it is closely allied to the preceding. I have not met with it west of the dividing range, but have traced it up the eastern slope nearly to the summit at South Pass, Wyoming.

Locusta fuliginosa, nov. sp.

Male.—Elytra and wings very long, nearly twice the length of the body. Wings dark fuscous, with short pellucid bands between the nerves.

Occiput is divided into three obtusely rounded, longitudinal ridges, the middle the broadest; the tubercle between the eyes compressed laterally, and sulcate. Pronotum short, lateral carinæ distinct on the posterior lobe; the second transverse impression bends backward on the dorsum, so as to form an acute angle; front sub-truncate; posterior extremety obtusely rounded; the entering angle of the posterior margin situated a little below the humerus, and is simply a rounded notch; the lower margin of the sides rounded, in a somewhat semi-circular form, from the anterior angle to the notch before mentioned. Elytra very long, nearly equal to twice the length of the body, of moderate width, margins parallel, apex round. Wings nearly as long as the elytra; the nervules very minute, almost imperceptible, except near the inner margin, where they are a little more prominent. The superanal plate is divided nearly to its base, the two lobes prolonged into pointed processes reaching the tips of the cerci; the cerci very stout, rounded exteriorly, somewhat carinated internally, apex rounded externally, internally there is a notch with a spine each side of it; subanal plate triangular at the apex, with two converging carinæ beneath, which terminate in the cylindrical appendages. All the femora furnished with two rows of spines, irregular, and but few on some of the carinæ. Anterior tibiæ with a single row of two or three spines in front; the middle tibiæ with two rows above, five in each, opposite; posterior tibiæ with two rows beneath. The prosternal spines sharp; the lateral angles of the meso and meta-sternum are also produced into dull spines, the latter the most obtuse. Spine of the anterior coxa broad at base, pointed at the apex.

Color, (dried.)—Fuliginous. Labrum pale yellow; a bright-yellow spot between the eyes, at the base of the tubercle; face dull yellow, variegated with dark brown; joints of the maxillary palpi fuscous at the base and pale at the tip; antennæ pale testaceous, the first and second joints fuscous. Pronotum palest on the dorsum; the upper posterior parts of the sides darkest. Elytra semi-pellucid, with a fuliginous shade, varied with darker spots, those along the middle field largest; stridulating organ scarcely differing in color from the other parts. Wings fuliginous throughout, varied only by short semi-pellucid bands reaching from one nerve to another, always situated between the nervules. Legs fuscous, the tibiæ palest. *Female*, unknown.

Dimensions.—Length of the body to tip of the cerci, 1.26 inches; cerci, .19 inch; elytra, 2.28 inches; posterior femora, 1.26 inches; posterior tibiæ, 1.33 inches.

From Northern Arizona. Obtained from the collection of Dr. Palmer, in the Agricultural Department, at Washington.

This is a very interesting species, as it is the first of this genus, as at present restricted, which has been found in the United States. I have therefore made my description very full, including some generic characters. It is remarkable for the length of its wings and its dark, somber color.

Figured by Professor Glover. Pl. I, Fig. 9.

L. occidentalis, nov. sp.

Female.—Testaceous, with a row of black spots along the middle of the elytra. Closely allied to *L. fuliginosa*, but smaller, and rather more slender in its proportions.

Occiput not ascending, convex, transverse; tubercle compressed on the sides, slightly sulcate. First joint of the antennæ convex in front, with a slight tubercle at the base. Pronotum longerthan broad, somewhat carinated; lateral carinæ rounded on the anterior lobes, angled on the posterior, slightly converging near the middle; a faint medium line visible; margins as in *fuliginosa*. Elytra about twice the length of the body; narrow, equal width throughout; round at the apex. The sternal spines and lobes as in *fuliginosa*. Middle femora longer than the anterior, slender sub-cylindrical; the anterior femora have from three to five small spines on the inner carina; middle and posterior femora have a few minute distant spines on each carina. Anterior tibiæ with one row of three spines in front; middle with two rows above, four or five in the internal, and two in the external.

Color, (dried, but does not appear to have been immersed in alcohol.)—Testaceous. Face pale brownish-yellow; an irregular black stripe reaches from the eyes to the posterior margin of the pronotum, running along the side of the latter, immediately below the lateral carina. The pronotum brownish above, paler below the stripe on the side. Elytra testaceous, the middle field marked with a row of black spots, which form a kind of serrature along the externo-median nerve, the interspaces whitish; the upper field somewhat regularly variegated with pale, brownish, rhomboid spots; lower field pale, with clusters of dark points. The wings fawn-colored; nerves and nervules of the front margin black, prominent; rest mostly the color of the wings, and less prominent. Spines tipped with piceous; soles of the tarsi fuscous. Antennæ wanting in my specimen.

Dimensions.—Length of body, .95 inch; elytra, 1.80 inches; posterior femora, 1.14 inches; posterior tibiæ, 1.13 inches; ovipositor, .97 inch.

California. Received from Mr. Taylor, of San Francisco, as a California species. Pl. II, Fig. 16.

CONOCEPHALINI.

Copiophora mucronata, Thos., (Canadian Ent., 1872, p–.)

Cone of the vertex smooth on the margins, mucronate. Mesosternu bidentate. Green; labrum, clypeus, and under side of the cone yellow.

Male and female.—Cone of the vertex standing obliquely forward, apex mucronate; the minute spine slightly deflexed, especially in the female; sides parallel from the base a little above the first joint of the antennæ, where they are slightly angulate; not serrated or granulate; front side has, near the base, a prominent tubercle; there is also a tubercle below this between the antennæ. Face oblique, smooth; occiput smooth;

pronotum rounded, not carined, densely punctured; on the dorsum there is generally a glabrous, semicircular spot; there are also some irregular glabrous impressions on the sides; front rounded; posterior margin nearly straight, slightly rounded at the humerus, where there is an entering angle. Elytra passing the abdomen about one-third their length; upper margin straight from the dorsal angle; lower margin rounded from the base to the apex; apex angled. Wings about as long as the elytra. Ovipositor about as long as the body, nearly straight, lanceolate at the apex; cerci of moderate length, swollen, slightly curved, with a slender, pointed apex. Posterior lateral angles of the mesosternum furnished with a strong spine. External carinæ of the femora furnished with strong spines; also a sharp spine each side of the apex of each, projecting forward. Anterior tibiæ without spines in front; middle with two rows above, two in each row; posterior with two rows beneath. Anterior coxæ furnished externally with a strong-curved spine. The abdomen of the male has, at the apex of the last ventral segment, the usual cylindrical appendages; superanal plate bilobed; no cerci apparent in the only male I have seen. Legs of the male quite hairy.

Color.—Body and elytra uniform bright pea-green; under side and edges of the frontal cone bright-yellow; labrum and clypeus yellow; mandibles deep piceous black, except the upper external angles, which are green; ovipositor dull yellow, slightly striped with fuscous near the apex; tarsi pale fuscous; eyes brown.

Dimensions.—♀, length (exclusive of cone) to tip of abdomen, 1.5 inches; cone, .3 inch; elytra, 1.28 inches; posterior femora, .87 inch; posterior tibiæ, .83 inch; ovipostor, 1.5 inches. ♂, length, 1.25 inches; elytra, 1.05 inches.

♀, Fig. 14, Pl. viii; ♂, Fig. 8, Pl. vii, of Professor Glover's plates of *Orthoptera.*

This species was obtained by Professor Glover in the greenhouse of the Agricultural Department at Washington. It has evidently been introduced with the plants brought from some tropical section. The only plants received last fall or winter from the tropics were from Central America and Cayenne.

If the mesosternal spines, which are very prominent, do not distinguish it from other species, the very interesting inquiry arises, Has it been produced from the eggs of some known species, the variations between the perfect insects having been produced by the different circumstances under which they have grown to maturity? So far as I am aware, the following list embraces all the species hitherto described:

C. cornuta, Serv.—Para.
C. Mexicana, Sauss.—Mexico.
C. lucifera, Burm.—Bahia.
C. flavo-scripta, Walk.—Venezuela.
C. longicauda, Serv.—Cayenne.
C. megacephala, Burm.—Isle St. Johanna.
C. gracilis, Scudd.—Napo, or Maranon.
C. cuspidata, Haan.—Brazil.

Although not from the West, I have given a description of it here on account of the interest which attaches to it.

Ephippitytha gracilipes, Thos.

I did not meet with this species west of the mountains, but find it among Dr. Palmer's collections, marked Northern Arizona. Plate II, Fig. 11.

FAMILY II.—ACRIDIDÆ.

Sub-family ACRIDINIÆ.

First group.—*Truxalini.*

OPOMOLA, Erichs.

*O. brachyptera,** Scudd., (Bost. Jour. Nat. Hist., VII, 454.)
Thos., (Proc. Phil. Acad. Nat. Sci., 1871.)

As Mr. Scudder at the time he described this species had but a single male specimen, I have concluded to give a full description of the unique female specimen I obtained in Wyoming Territory.

Female.—Vertex carinated; elytra narrow, reaching the tip of the second abdominal segment. Antennæ broad, ensiform. Pale orange-brown, with dusky points.

Occiput convex, straight, not ascending, with a slight, shallow, longitudinal depression each side, leaving a low, rounded, median ridge. Vertex triangular, margins turned up, with a strong median carina, the three meeting in front in a blunt point; length, in advance of the eyes, equal to about one-third of the entire length of the head. The face tricarinate, or rather quadricarinate, as the frontal ridge is so deeply sulcate that it forms two distinct carinæ, which meet at the vertex; all somewhat divergent, and reaching the clypeus. Eyes oblong-ovate. Antennæ scarcely as long as the head and thorax, ensiform, flattened, and slightly triquetrous. Pronotum about as long as the head, tricarinate; sides parallel; only the posterior transverse impression distinct on the disk, situate a little behind the middle. Elytra lanceolate, narrow, reaching the tip of the second abdominal segment. Wings narrow, minute, about half as long as the elytra. Abdomen long, slender, and somewhat cylindrical, slightly carinated. The four anterior legs slender; posterior femora, slender, straight, not as long as the abdomen; posterior tibiæ slender, nearly cylindrical, somewhat hairy at the apex. Prosternal point is only a blunt tubercle.

Color, (dried, after long immersion in alcohol.)—Pale orange-brown, without distinct spots or markings, but with numerous minute dusky points. The antennæ are purplish brown; the vertex, legs, and abdomen tinged with the same color. Spines of the posterior tibiæ, abdominal appendages, and tarsal claws tipped with black. When living, the only specimen I have seen in the perfect state, was of a uniform grayish-brown; length, 1.5 inches.

My specimen was obtained near the ruins of old Fort Casper, on the North Platte River, Wyoming Territory, August 22. I have some larvæ and pupæ obtained in Cache Valley, Utah, which possibly belong to this species.

O. Wyomingensis, Thos.

Syn., *Mesops Wyomingensis*, (Proc. Phil. Acad. Nat. Sci., 1871.)

Small, slender, and cylindrical; elytra reaching the fifth abdominal segment; abdomen of the male terminating in an acute prolongation. Pale green, sometimes varied with reddish, immaculate.

* This specific name is twice used; the *Acridium* (*Pyrgomorpha*) *brachyptera*, Haan, (Verz. Nat. Gesch. Ned. Ind. Bez. Ins., 150,) having been referred by Walker to *Opomola*, becomes *O. brachyptera*, but Mr. Scudder's species received the name first, hence must stand, and that of Walker changed. (See Walk. Cat. Dermop. Salt., III, 514.)

Female.—Frontal cone elongate, flat above, scarcely margined, a shallow foveola each side under the lateral margin. Face very oblique, quadricarinate; carinæ sharp, divergent, reaching the clypeus. Eyes oblong-ovate, situated near the antennæ. Antennæ ensiform, triquetrous. Pronotum about as long as the head; anterior and posterior margins truncate; cylindrical. Elytra narrow, lanceolate, reaching the fifth abdominal segment; wings small. Abdomen elongate, cylindrical, slightly enlarged toward the apex; upper valves of the ovipositor scarcely exserted. Prosternal spine quite short and blunt. Mesosternum slightly furrowed longitudinally on each side.

Color.—Bright pea-green, immaculate; wings pellucid. After immersion in alcohol it becomes a pale greenish-yellow.

Male.—Differs from the female, as follows: Much smaller and slenderer; vertex more pointed, slightly margined; abdomen turned up at the apex, terminating with a sharp lanceolate extension of the last ventral segment; antennæ, face, vertex, occiput, pronotum, femora, and abdominal appendages more or less varied with pale carneous; a whitish stripe extends from the lower border of each eye to the base of the middle leg.

Dimensions.—♀, length, 1.05 inches; elytra, .52 inch; posterior femora, .5 inch. ♂, length, .78 inch.

Found on the east side of the Black Hills, Wyoming, in the vicinity of Cottonwood Creek. August.

I formerly placed this in *Mesops*, with which it agrees in all respects, except the position of the eyes, which appears to be the distinguishing character of that genus. I have, therefore, concluded to place it in *Opomola*, in Walker's second group, of which *O. cylindrodes*, Stål., is the type; yet I believe it would be better to slightly modify the generic description of Mesops and place it there, for it appears to be very closely allied to *M. pedestris*, Erichs. Certainly it agrees more closely with the characters of this genus (except as to the position of the eyes) than *M. gladiator*, Westw. Pl. II, Fig. 8.

Second group.—*Acridini.*

ACRIDIUM, Geof.

A. ambiguum, nov. sp.

Male and female.—Very similar in size, markings, and carvings to *A. Americanum*, Dru., with which it has been long confounded, and from which it differs chiefly, and almost exclusively, in the general color. The *A. Americanum* is more deeply and closely punctured about the head than the latter. In the former the frontal costa, besides the smaller punctures, has along each margin a row of regularly spaced large black punctures, which are less distinct, or wanting, in the latter, *(ambiguum.)* The spots on the elytra of the latter are scarcely as large and paler than in the former.

Color.—Yellow or brownish-yellow. Face yellow; occiput pale brown. Dorsum of the pronotum light brown; the dorsal stripe dim, and sometimes, especially in the male, absent. Sides of the pronotum yellow; a dusky spot in the middle with a yellow stripe through it. Wings transparent, with a pale-yellowish tinge at the base; veins of the apex and of the anterior portion black. Brownish spots on the elytra, much like and arranged as in *A. Americanum;* general color of the rest yellowish, or brownish-yellow. Abdomen greenish-yellow. Legs bright yellow; femora reddish above.

Dimensions.—♀, length, 2 inches; elytra, 1.95 inches. ♂, length, 1.6 inches; elytra, 1.74 inches; posterior femora, 1 inch; posterior tibiæ, .9 inch.

Southern Illinois; Kansas, (Thomas;) Tennessee, (T. Rogan, esq.)

There has been much confusion in regard to the *A. Americanum*, (with which the present species has, doubtless, been confounded,) notwithstanding its large size, distinct markings, and the very full description given by Drury as early as 1770, with an accompanying colored figure. The markings and carvings of the two species are nearly exactly alike; but the general or ground colors are very different, the one being a deep vermilion or purplish-red, and the other a dull yellow, or light brownish-yellow. But, in addition to this difference, I am satisfied, after a close observation of the two in Illinois for several years, that they are different species from another fact: the *A. ambiguum* always appears in the spring, in April or May, while the other never appears earlier than the middle of July; and from quite a number of specimens of each sent me the past season from East Tennessee, by Theophilus Rogan, esq., of Russellville, I am satisfied the same thing occurs there. The *A. Americanum* made its appearance in Washington City this season in the latter part of August and first of September; but not a specimen of the other species was to be seen among them. The two species differ considerably when on the wing, the wings of the *A. Americanum* having a peculiar silvery appearance not observable in the other. The larvæ also are different, those of the former being reddish-brown, while the latter is greenish.

De Geer (Mem. Ins., III, Pl. 40, Fig. 8) figures probably a specimen of my *ambiguum*, which he names *A. flavo-fasciatum;* but Serville's description under this name applies to an entirely different species. Olivier's *A. vittatum*, (Encyc. Method Ins., VI, 221,) which he gives as synonymous with De Geer's species, is also a different insect. De Haan, who received specimens from Tennessee, through Dr. Troost, undoubtedly of my *ambiguum*, says (Bijdr. Kenn. Orthop., 143) that *A. carneipes*, Serv., is but a variety of *A. flavo-fasciatum*, to which he refers his specimens, thus evidently making two mistakes. Westwood, in his edition of Drury, gives the name *Locusta tartarica* to his figure of this species, thus identifying it with *Gryllus tartaricus*, Linn., one of the destructive oriental species.

Professor T. Glover figures *A. Americanum* under the name of *A. rusticum*, probably after Burmeister, whose description evidently applies to *A. alutaceum*, Harr. Walker (Cat. Dermap. Salt., III, 550) transfers *A. Americanum* to his new genus, *Cyrtacanthacris*, to which, if correct, we should also transfer the other species. But his only generic description is, that the posternal spine is bent or curved obliquely backward upon the mesosternum, adding that it corresponds with Serville's Div. 1 and Burmeister's Div. 2A of *Acridium.* Now Serville states as one of the chief characters of his Div. 1 that "the subanal plate of the male is long, triangular, entire, and pointed," while both these species have the subanal plate very distinctly and strongly notched, which places it in his second division, subdivision *qq.*

In this state of confusion I have concluded to give a new name to the yellow species, as it does not appear to have been distinguished from *A. Americanum*, although it has doubtless been referred to by some of the authors mentioned.

A. frontalis, nov. sp. Pl. II, fig 1.

Vertex sub-conical, small size; elytra and wings not passing the abdomen. General color green. Closely allied to *A. unilineatum*, Walk.;

caloptenoid in general appearance. Vertex regularly hexagonal, standing out in the form of a short truncated cone, the tip depressed in the center; face slightly oblique, straight, quadricarinate; carinæ nearly parallel, middle pair approach each other immediately below the ocellus. Eyes elongate, oblique, straight in front. Pronotum scarcely enlarged behind; anterior lobes reticulately, and posterior lobe longitudinally, rugulose; median carina very distinct, but not elevated. Elytra and wings narrow, rather shorter than the abdomen. Valves of the ovipos itor prominent, the lower pair much slenderer than the upper and much exserted. Male cerci slender, tapering and curved upward; subanal plate narrow, tapering, subtruncate at the apex, entire. Prosternal spine subquadrate, pointed, and straight. Antennæ passing the pronotum slightly. Posterior femora passing the abdomen.

Color, (dried after immersion in alcohol).—Nearly uniform greenish-yellow. Face and pronotum sprinkled with dusky dots. The elevated lines of the pronotum pale yellow; depressed portions in the alcoholic specimens testaceous-green, but in the living insect may be and probably are colored quite differently; some specimens have the middle carina and other portions of the pronotum tinged with red. Posterior femora pale reddish along the upper edge. Elytra a transparent green; wings pellucid.

Dimensions.— ♀, length, 1.06 inch.; elytra, .63 inch.; posterior femora, .72 inch.; posterior tibiæ, .66 inch. ♂, length, .82 inch.; elytra, .5 inch.

Kansas, (from C. R. Dodge's collection.)

There is a possibility that this is synonymous with *Pezotettix speciosa*, Scudd., (Hayden's U. S. Geol. Surv. Neb., 250,) with which it agrees tolerably well except in the length of the elytra and wings; but Mr. Scudder may have had the pupæ, and he places it in *Pezotettix* provisionally, "as it does not strictly appertain" to that genus. It is a somewhat anomalous species, but I think my specimens belong to *Acridium*.

A. emarginatum, Uhl., (Scudd., Notes on Orthop., Geol. Surv. Neb.)

This species is closely allied to and much like *A. alutaceum*, Harr. It is the same one which I, in my former report, referred to *A. flavo-faciatum*, DeG. It has been found in Southeastern Colorado and in Nebraska, but appears to be rarely met with.

Caloptenus, Burm.

The following table of the species belonging to the United States will give the distinguishing characters of the new species herein described:

A. Elytra without spots:
- *a.* A broad yellow stripe along each lateral angle...... *bivittatus.*
- *aa.* With but one or no dorsal stripe:
  - *b.* General color green, a yellow dorsal stripe .... * *viridis.*
  - *bb.* Dorsum not striped:
    - *c.* Elytra a little longer than the abdomen; size, large .... *differentialis.*
    - *cc.* Elytra much shorter than the abdomen; size, small ....* *Dodgei.*

AA. Elytra with spots:
- *a.* Elytra longer than the abdomen.
  - *b.* Elytra much longer than the abdomen; last ventral segment of the male notched at the tip .... *spretus.*

bb. Elytra slightly longer than the abdomen; last ventral segment of the male entire at the tip:
c. Spots small, and confined to a median line along the disk ....*femur-rubrum.*
cc. Spots larger, and equally distributed over the elytra ....* *griseus.*
aa. Elytra about as long as the abdomen.
b. General color pale yellow:
c. Hind femora with two oblique black streaks outside ....*bilituratus.*
cc. Hind femora with three black patches outside..*scriptus.*
bb. General color not pale yellow:
c. Hind femora with three straight black bands; lower valves of the ovipositor neary straight at the apex ....*punctulatus.*
cc. Hind femora with oblique brown bands; lower valves of the ovipositor bent at the apex......* *occidentalis.*
aaa. Elytra shorter than the abodmen:
b. Color, pale olive-green; a pale stripe each side the pronotum ....* *Turnbullii.*
bb. Color tawny; head and thorax with two broad black stripes ....*repletus.*

C. viridis, nov. sp. Pl. II, fig. 3.

Lateral carinæ of the pronotum obsolete. Green, with a white dorsal stripe; femora banded with red.

Vertex slightly expanding in front of the eyes, channeled; lateral carinæ of the face moderately divergent; frontal costa sulcate and narrowed below the ocellus. Eyes elongate, large, acuminate above, and approaching unusually near to each other. Pronotum sub-cylindrical; lateral carinæ obliterated; median carina scarcely perceptible; the posterior lateral margins nearly straight from the lateral angle to the apex, there being no entering angle at the humerus, this point of the margin being marked only by a slight inward flexure; the posterior transverse incision only cuts the median carina. Cerci of the male regularly acuminate; subanal plate entire, sub-truncate at the apex; superanal plate triangular with two sub-medial convergent ribs or carinæ. The elytra and wings about as long as the abdomen. The posterior femora reach the tip of the abdomen.

Color, (dried after immersion in alcohol.) Entirely of a pale greenish-yellow, except as follows: antennæ rufous; tip of the vertex, and a spot beneath the eye, (in most specimens,) fuscous; transverse incisions of the pronotum, and two short lines on the sides, dark. A slightly paler median stripe is visible on the occiput and pronotum, bordered by pale brown; posterior lobe of the pronotum tinged with roseate. Tips of the spines and claws black. Elytra and wings pellucid, immaculate.

The living insect is colored as follows: A bright pea-green, with a white stripe along the middle of the occiput and pronotum; and one along the angle of each elytron, and one along the edge of the hind femora. A bright red ring around each femur just above the knee; hind tibiæ blue. Male and female the same except in size.

Dimensions.— ♀, length, .85 inch; elytra, .62 inch; posterior femora, .5 inch. ♂, length, .62 inch.

Colorado, Wyoming, and Kansas.

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* New species.

It is probable that this species should be placed in *Ommatolampis*, but I am not sufficiently acquainted with that genus to determine this point.

C. Dodgei, Thos., Pl. II, figs. 4, 5, 9., (Canadian Ent., 1871, p. 168.)

Posterior femora with three white bands. Elytra not more than half the length of the abdomen, unspotted.

Male.—Small size. Vertex elongate, distinctly channeled; frontal costa broad, flat, and squarely margined above the ocellus; margins punctured; antennæ thick, passing the thorax; joints distinct and somewhat obconic. The transverse incisions of the pronotum distinct; posterior lateral margins very slightly incurved at the humerus; median carina distinct only on the anterior and posterior lobes. Elytra about half the length of the abdomen, oblong-ovate. Posterior femora about as long as the abdomen. Prosternal point thick, obtuse, transverse. Cerci slender; subanal plate somewhat pointed, the margin on the upper surface entire.

Color.—Brown, varied with white. Face cinereous. Occiput and disk of the pronotum dark brown, mottled with lighter and darker shades, except the posterior lobe, which is brown. Elytra brown, lower half very dark; on each side of the head and pronotum behind the eye there is a dark glabrous spot, which does not extend back beyond the third transverse incision. Abdomen pale, mottled with reddish-brown. Four anterior tibiæ pale reddish-brown. A white oblique spot above the posterior coxæ. Posterior femora crossed externally by three white bands, the one nearest the apex much the smallest; the middle intermediate dark band is abruptly bent forward in the middle of the disk. Antennæ pale at base; rest rufous.

Female.—Pronotum uniformly dark brown, except the dark spots on the sides, and the posterior lobe of the pronotum, which is a bright reddish-brown. The elytra extend over but two segments. Abdomen brown. This may not be the female of this species, as it varies considerably, and was not captured where the males were.

Dimensions.— ♀, length, .85 inch; elytra, .2 inch; posterior femora, .4 inch; posterior tibiæ, .32 inch. ♂, length, .56 inch; elytra, .18 inch; posterior femora, .37 inch; posterior tibiæ, .26 inch.

Collected on Pike's Peak, Colorado, by Mr. C. R. Dodge, of the Agricultural Department, in honor of whom it has been named. The female was captured in the neighborhood of the peak, but not on it; at least Mr. Dodge thinks it was not. I have been considerably puzzled in regard to the genus in which this falls; the short wings would place it in *Pezotettix*, but the form of the pronotum and cerci would appear to place it among the *Calopteni*, and therefore I have allowed its general appearance to prevail over the single character, short wings and elytra.

C. femur-rubrum, Burm.

Although Walker mentions this species as occurring at Vancouver's Island, yet I have found no specimen west of the dividing range of the Rocky Mountains that I can refer to this species.

C. spretus, Uhler, (MSS.)

Found the past season in great abundance in the north part of Salt Lake Basin. When we reached Ogden, June 1, I saw but very few specimens; but when we reached Box Elder Cañon, two weeks later, the larvæ were seen spreading out from points where they had evidently been hatched. When we passed through the hills to Cache Valley, a few miles farther, and but a few days later, I found them just entering their

perfect state. By the time we reached the north end of this valley, about the 20th of June, they were taking wing and proceeding southward. Here, the farmers, who have observed them closely for a number of years, say that they never lay their eggs in the lower level of the valley, but universally on the gravelly, elevated terraces. So positive are they on this point that one farmer, to test the matter, last year offered five dollars for every bunch of eggs that could be found on the lower valley-level which had been deposited there by the insect itself, but none were brought to him. I think, therefore, we may conclude that it is pretty well settled that the usual hatching-grounds of the destructive swarms are on the gravelly terraces or uplands. Yet that considerable numbers are hatched in the narrow cañons of the moderately elevated mountains I think is also certain, as I observed this year a large number of larvæ in Box Elder Cañon, but the elevation of this cañon is little, if any, more than that of Cache Valley. When I returned to Salt Lake Basin, early in August, I found the country swarming with myriads of these grasshoppers. And even after we had passed eastward on the railroad, to the heights near Aspen Station, I noticed the air filled with their snowy wings, but could not tell exactly the course they were taking, but thought they were moving southwest.

As this species has never been described in its preparatory state, I give here a short description of the pupa, written in the field with myriads of living specimens around me:

General color yellow, (sometimes varied to light brown, and at others a pale pea-green,) with a large proportion of black spots and stripes, also a few white dots and lines; labrum and lower part of the face mostly black; upper part of the face, the vertex, and cheeks yellow, (or the prevailing color;) a row of black dots on each margin of the broad, sulcate, frontal costa; occiput with two lateral and one median dotted lines of black; a broad line of deep black starts behind each eye, and crosses over the entire length of the pronotum, widening and bowing upward near the middle of the pronotum; the immature, somewhat fan-shaped elytra are black, with a white dot on the disk near the base, from which proceed about ten or twelve white rays; the dorsal or upper margin yellow; dorsal and lateral portions of the abdomen varied with white and black; a triangular black dot on each side of each segment; tip and venter yellowish.

C. Turnbullii, nov. sp. Pl. II, fig. 10.

Pale olive-green, with a white stripe along each side of the dorsum; elytra and wings shorter than the abdomen. Closely allied to *C. viridis*, Thos.

Vertex with a broad, shallow sulcus, into which a minute raised line or carina (not always apparent) enters from the rear; frontal costa flat, slightly divergent on the posterior lobe; lateral obtuse carinæ somewhat more distinct* than in *C. viridis*. Elytra and wings a little shorter than the abdomen; cerci of the male flat, narrow, and tapering; last ventral segment with a blunt tubercle below the margin; posterior femora rather more than usually enlarged near the base, about as long as the abdomen; prosternal spine somewhat quadrate, but tapering rapidly. The females are thick and fleshy.

Color, (dried after immersion in alcohol.)—Dull yellow, or testaceous;

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*Yet these are really not true carinæ, but only the obtusely rounded shoulders or lateral margins of the pronotum. And I doubt very much the propriety of calling these rounded angles carinæ in any of the *Calopteni*, as this use of the term leads to confusion, as, in fact, no species of *Caloptenus* have true lateral carinæ to the pronotum.

a broad, yellowish stripe on each side, from the upper angle of the eye to the tip of the pronotum; the inclosed middle space pale brown; median carina yellowish. Below the yellow stripes, on each side, is a broad, irregular brownish stripe, reaching from the eye to the tip of the pronotum. A bright yellow stripe runs from the base of the elytra to the posterior coxæ. Elytra pale ash-brown, with an irregular row of rather small, dim brown spots along the disk, one or two sometimes distinguishable above and below; nervules mostly yellow; wings pellucid, with some dark nerves near the apex; posterior femora crossed by three oblique, dim brown bands; tibiæ bluish. When living, it is of a pale pea-green, the dorsal stripes whitish; hind tibiæ blue.

Dimensions.—♀, length, .76 inch; elytra, .43 inch; posterior femora, .43 inch. ♂, length, .56 to .60 inch.

There is a strongly marked variety, which I have included in this species, but which may be distinct.

Var. *a.*—Paler throughout; space between the stripes almost uniform in color with the stripes; lateral brown stripes often narrower or obliterated; elytra, narrower and longer, reaching nearly or quite to the extremity of the abdomen. The male appears to be uniformly longer and larger.

Named in honor of Dr. Charles S. Turnbull, of Philadelphia, who first discovered it.

Found only between Red Buttes and Independence Rock, Wyoming.

C. occidentalis, nov. sp. Pl. II, fig. 2.

Much like *C. femur-rubrum*, Burm. Male cerci very broad and flat; hind femora banded; tibiæ blue.

Frontal costa generally flat above the ocellus and sulcate below it, but sometimes sulcate above; lateral carinæ sharp and divergent; median carina distinct on the posterior lobe of the pronotum, barely visible in front; the transverse impressions very distinct; elytra and wings as long as the abdomen; anterior and middle femora rather small and slender; posterior femora, in the female, a little shorter than the abdomen; valves of the ovipositor, especially the upper ones, long and deeply excavated. The cerci of the male are unusually broad and flat, enlarged at the base and suddenly decreasing in breadth near the middle; the last ventral segment apparently terminates at the tip with a broad, blunt tooth; prosternal spine broad at base, blunt and transverse.

Color, (dried after immersion in alcohol.)—Much like *C. femur-rubrum*, but more of a pale, ashen hue; face dull brownish-yellow; a triangular dusky spot on the occiput, with the apex toward the front; a crescent of minute black dots around the back part of the eyes; the dark band behind each eye as usual; pronotum pale reddish-brown above. Elytra ash-brown, with a row of small brown spots along the middle of the disk, reaching from near the base two-thirds the distance to the tip, ceasing, or growing dim, at the point where the nervules become suddenly less distinct; a few dots are found above and below this middle row in some specimens. Wings transparent; nerves yellowish, except at the apex, where they are dusky. The posterior femora are crossed by three oblique brownish bands—inside, yellowish; apex, dusky: tibiæ, bluish-yellow; blue, when living.

Dimensions.—♀, length, .88 inch; elytra, .60 inch; posterior femora, .47 inch. ♂, length, .69 inch.

Found in Eastern Wyoming, from the mouth of Laramie River to Red Buttes.

C. griseus, nov. sp.

Head quite large; occiput elevated. Dark gray, with fuscous and yellowish spots.

Female.—Occiput unusually convex and prominent; seen from the side, the top of the head rises considerably above the disk of the pronotum; lateral carinæ of the face but slightly divergent. Posterior lobe of the pronotum densely punctured. Elytra passing the abdomen one-fourth their length. Upper and lower valves of the ovipositor slender, without any lateral angulations, not much excavated. Posterior femora passing the abdomen. Prosternal spine short, obtuse, and slightly transverse.

Color.—Face lurid, with numerous small, black spots. Occiput and pronotum gray, with a slight brassy tinge, irregularly spotted with black; behind each eye, reaching to the last cross-incision of the pronotum, is an interrupted, broad, piceous stripe; the sides of the pronotum below this are somewhat lurid. Elytra dark gray; nervules whitish, marked somewhat regularly with subquadrate black or fuscous spots, not confined to the middle field, but extending equally above and below, becoming dimmer toward the extremity, but distinct. Wings (not spread in the only specimen seen) appear to be dusky toward the apex. Posterior femora with three yellowish bands; rest of the disk black, sulcus beneath, and interior carina bright red; tibiæ purplish-red beneath, with a pale ring near the base; spines black; legs hairy. Venter yellowish.

Dimensions.—Length to tip of the elytra, 1.08 inches; elytra, .76 inch; posterior femora, .52 inch; posterior tibiæ, .45 inch.

Ohio, (from Mr. Dodge's collection.)

PEZOTETTIX,* Burm.

Including the new species herein described, there are eleven species belonging to this genus found in the United States that have been determined and named, four of which are found west of Missouri, to wit: *P. Borckii*, Stal., *P. picta*, Thos., *P. obesa*, Thos., and *P. Nebrascencis*, Thos.

P. obesa, nov. sp. Pl. II, fig 13 and 14.

Prosternal spine very short and obtuse; body of the female robust, fleshy; elytra and wings wanting.

Vertex broadly sulcate, the raised margins slightly angulate in front of the eyes, and continuous with the margins of the frontal costa; frontal costa broad, flat, and slightly sulcate at the ocellus, not reaching the clypeus; lateral carinæ distinct but not prominent. Pronotum short, expanding slightly posteriorly, truncate; the median carina distinct, continuous; lateral carinæ scarcely distinct on the posterior lobes, more distinct on the front lobes; transverse impressed lines indistinct; truncate in front and behind; the posterior margin straight like the posterior margin of an abdominal segment, (in fact, the parts of the thorax look almost exactly like the abdominal segments,) not covering the meso-notum, but extending only to the middle

* Walker (Cat. Dermap. Salt.) has restored *Podisma*, Latr., which probably has priority, but I retain Burmeister's name, as we thus do away with a number of synonyms. This genus does not appear to be well defined, and it is extremely difficult to determine the line of demarkation between it and *Caloptenus*. I am of the opinion that the posterior lateral margins of the pronotum will afford a good character, as the true *Pezotettigi* which I have seen appear to have these straight without an entering angle at the humerus.

of it; the transverse, impressed lines indistinct, the third only crossing the median carina. The meso-thorax and meta-thorax appear on the dorsum as abdominal segments. Genital organs not prominent; in the female the upper valves of the ovipositor protrude but slightly beyond the last segment, the lower valves somewhat elongate; cerci broad at base and short, the tip of the last ventral segment (or subanal plate) somewhat three-pointed. The male abdominal appendages of the usual form. Posterior femora in the female considerably shorter than the abdomen—about equal to it in the male. Prosternal spine almost obliterated, being shortened to a simple tubercle. Antennæ short, sub-moniliform; joints very short. It is entirely apterous, without sign of elytra or wings.

Color, (of the living insect.)—General color dull olive-brown; disk and sides of the pronotum and abdomen olive. There is a black line on the occiput; lateral carinæ of the face and margins of the frontal costa black. Female appendages tipped with red. Posterior legs are colored as follows: femora dark olive-green or black; a pale yellowish stripe along the lower exterior margin, the lower outer carina olive-red, channel black, inner portion yellow with two oblique, black bands; tibiæ black at the base; patella red, upper part of the exterior dark blue, changing downward to purplish, vermilion at the apex, inside yellow; spines yellowish at base, tipped with black; tarsi red above, whitish beneath. The other tibiæ are colored as the posterior. Dried specimens, after immersion in alcohol, are colored as follows: dorsum dark reddish-brown; head and face paler, the black markings of the carinæ remaining. Lower portions of the sides of the pronotum a shining yellow color. A pale line along the median carina of the abdomen. Disk of the posterior femora dark brown; upper and lower exterior margins yellow; channel beneath black; upper carina black; two bands and a spot at the base, and another at the apex, black. Patella (or tubercle at the base of the tibiæ) yellow; and a narrow black band just below this; remainder of the tibiæ brownish-purple. Venter and pectus dull yellow.

Dimensions.—♀, length, 1.05 to 1.12 inches; posterior femora, .5 inch; posterior tibiæ, .43 inch. ♂, length, .76 inch.

Found on the dividing range of the Rocky Mountains between Idaho and Southern Montana; and on a ridge about 8,000 feet above the level of the sea, some forty miles southwest of Virginia City, Montana.

This species will probably have to be placed in some other genus. It appears to be closely allied to *Dactylotum*, Charp.; but that author has not given the generic characters with sufficient accuracy for me to decide the point. I have given the characters somewhat particularly to enable those who may not have specimens to judge as to its generic position.

P. Nebrascencis, nov. sp.

Female.—Occiput and head behind the eyes unusally long; upper convex portion of the frontal costa very prominent, extending in front of the eyes equal to their width; the frontal costa suddenly expands in width immediately above the ocellus, and is slightly sulcate from this point to the lower extremity near the clypeus; face somewhat oblique or curved inward toward the breast; eyes slightly elongate, oblique, nearly straight in front. Pronotum sub-tricarinate; median carina distinct; lateral carina obtusely rounded and nearly obliterated; sides parallel, narrower than the head, rounded at the apex; posterior lateral margin without any notch or inward curve at the humerus. Elytra

ovate-lanceolate nearly half the length of the abdomen. Abdomen distinctly carined. Posterior femora not passing the abdomen.

Color, (dried after immersion in alcohol.)—Reddish-brown. Face testaceous-brown; occiput brown, with a yellowish stripe each side; a glabrous black spot behind each eye, extending along each side of the pronotum to the posterior incision. Disk of the pronotum brown; a pale, testaceous spot on the sides below the black stripe. Elytra brown and unspotted, though in a few specimens very indistinct, dusty dots can sometimes be observed. Posterior tibiæ reddish; brown exteriorly, yellowish beneath, (when living probably are like *C. femur-rubrum*.)

Dimensions.—Length, .94 inch; elytra, .25 inch; posterior femora, .50 inch; posterior tibiæ, .45 inch.

Nebraska, (from the collection of Mr. C. R. Dodge.)

ŒDIPODINI.

ŒDIPODA, Latr.

There are now, including the new species herein described, thirty-six species of this genus known in the United States. I have been unusually favored in my investigations of this genus, as I have had before me specimens of thirty-one out of this number. Twenty-four species of this genus are found west of Missouri, twenty of them being peculiar to that region, so far as known. As will be seen, I have added eight new species to this already extensive group.

Œ. trifasciata, Walk., (Cat. Dermap. Salt., IV, p. 729.)

Syn., *Gryllus trifasciatus*, Say, (Amer. Ent., III, Pl. 34.)

Pl. I, Fig. 6.

While at Cheyenne, during the last days of May, I noticed a number of individuals belonging to this species in the pupa state, but saw none that had yet acquired their full growth. I met with occasional specimens in Utah, around Ogden, but many of these vary considerably from the type, the black band across the wing being much broader, and the dark bands across the elytra less distinct. In fact, some of these vary to such an extent that I have strong doubts in regard to their specific identity, yet, as the variations are not regular, I have refrained from describing them as new.

Œ. Haldemannii, Scudd., (Hayden's Geol. Rep. Neb., 253.)

Œ. corallipes, Hald., (Stansb. Rep., 371, Pl. 10, Fig. 2.)

These two species are very closely allied to each other, and I have much doubt in regard to their being distinct. The former is described by Mr. Scudder in his report on the *Orthoptera* collected by Professor Hayden in his geological survey of Nebraska, who claims that it is distinct from the latter. He says that it differs from the latter in the greater rugosity of the pronotum, and in the greater separation and distinctness of the markings of the elytra; but an examination of the numerous specimens I have from Colorado, Wyoming, Utah, and Nebraska shows every grade of difference, in these respects, from one extreme to the other. It is true the specimens from Nebraska correspond with Mr. Scudder's short description, but when we approach the mountains these differences somewhat decrease, and when we pass into Utah we find the other extreme, as given by Haldeman. I will

give here, from my field-notes, a description of a living specimen of what I supposed was *Œ. corallipes.*

Female.—Occiput mottled with dark-brown; a whitish spot behind the upper canthus of each eye; the vertex and the broad frontal ridge light ashy-blue, the margins of the ridge light-yellow; parts of the mouth pale carneous, the clypeus having the deepest tinge. That part of the neck which is mostly hid by the pronotum bright blue. The lateral carinæ of the pronotum have a tolerably broad pale stripe along the upper side of each. The whitish parts of the pronotum and elytra have a bluish tinge, except the stripes along the dorsal margin of the latter, which are pale yellow. The wings are a clear lemon-yellow at the base; the black band sends a broad ray up the front submargin nearly to the base; the marginal vein being yellow, the apex transparent, with dark nerves. The base of the abdomen dark bluish. The under side of the body light brownish-yellow; the pits or depressions in the sternum red. The four anterior legs a pale ashy-blue. Inside of the posterior femora and posterior tibiæ a bright coral-red. Spots of the elytra as described by Haldeman. Sometimes the whitish and ash colors of the head, pronotum, elytra, and legs are replaced by bright orange-yellow, but the dark brown spots and patches appear to be permanent.

At Ogden, in Utah, I met with a grasshopper, which in size, shape, markings of the elytra, carvings of the head, mode of flight, and some other respects, corresponds exactly with *Œ. corrallipes*, but the wings are red at base, and the interior of the posterior femora and posterior tibiæ are yellow. I supposed, after examining it, that it was a distinct species, yet after my return from the West, I am unable to distinguish the alcoholic specimens from the *Œ. corrallipes.*

The following field-note may be of some value to other collectors: As a provisional name I will call it *Œ. paradoxa.*

Vertex rather prominent; a reddish tinge prevails on the lighter parts of the whole insect; the lateral carinæ of the pronotum are bordered internally with a broad, whitish stripe; the stripes along the dorsal angles of the elytra are quite distinct, and the dorsal margin without spots; the wings are of an orange-red (sometimes cinnabar-red) at the base; the dark band crosses about two-thirds the distance from the base to the extremity; a dark stripe runs up the anterior border; apex transparent with dark nerves; the posterior femora inside, and the posterior tibiæ, bright yellow; the exterior face of the femora crossed by three irregular, oblique, dark bands; antennæ slightly enlarged, and apparently flattened near the apex. Found from Ogden to Smithfield, in Cache Valley.

The dark bands across the femora, and the slightly flattened antennæ are not unusual in the other species. I met with a single specimen of this red-winged kind in 1870, in Sweet Water Valley, Wyoming.

Notwithstanding these wide variations I would not be surprised if future investigations would show that not only these, but also *Œ. rugosa*, Scudder, (if I know that species,*) are but varieties of the same species. I see that Walker (Cat. Dermop. Salt.) gives Vancouver's Island as one of the localities where *Œ. rugosa* is found, and Indiana and Massachusetts as localities where *Œ. corrallipes* is found, thus, as I suppose, confounding the two.

The *Œ. neglecta*, Thos., which has a strong resemblance to the male

*I have received but one specimen from New England, marked *Œ. rugosa*, but this specimen was certainly marked erroneously, being a variety of *Œ. verruculata.* I have taken, at Washington, D. C., and in Illinois, specimens which correspond exactly with Mr. Scudder's description of *Œ. rugosa.*

of *Œ. corrallipes*, I am satisfied, after a thorough examination the present year of a number of specimens, is quite distinct, the head alone being sufficient to distinguish the one from the other.

Œ. Carolina, Serv.

Syn., *Gryllus (Locusta) Carolinus*, Linn.; *Gryllus Carolinus*, Fabr.; *Acrydium Carolinum*, Deg.; *Acrydium Carolinianum*, Pal. de Beauv.; *Locusta Carolina*, Harr.; *Locusta Caroliniana*, Catesby.

I have found this species in all parts of the West that I have visited, but never in great abundance. The specimens from the plains are generally a paler ash-color than those found east of the Mississippi. Walker (Cat. Dermap. Salt.) gives Vancouver's Island as a locality where it is to be found. If he is correct in this, then we need evidence only in regard to Southern Arizona and California to show that it is found throughout the United States.

Œ. Sulphurea, Burm.

Syn., *Gryllus sulphureus*, Fabr.; *Acridium sulphureum*, Oliv.; *Locusta sulphurea*, Harr.; *Tomonotus sulphureus*, Sauss.; *Gryllus (Locusta) sulphureus*, Gmel.

I did not meet with this species either in the Salt Lake Basin or Snake River Valley, but I have specimens from California which appear to belong to it, but they are rather too much damaged for me to decide positively. Walker (*loc. cit.*) gives Vancouver's Island and the west coast of North America as places where it is to be found. The specimens I have from California appear to be somewhat intermediate between *Sulphurea* and *Xanthoptera*, except that the size is rather small.

Œ. sordida, Burm. (Handb. Ent., II, 643.)

Syn., *Locusta periscelidis*, Say, (in Harr. Cat. Ins. Mass., 56;) *Locusta nebulosa* (Harr. Rep., 181;) *Acridium sordidum*, De Haan, (Kenn. Orthop., 143;) *Œdipoda nebulosa*, Uhl., Harr. Rep., 181;) *Œdipoda sordide*, Walk., (Cat. Dermap. Salt., IV, 732.)

I did not meet with this species west of or even at the east base of the mountains, but find it among the collections made by Mr. C. R. Dodge, in Nebraska.

Œ. atrox, Scudd., (Hayden's Geol. Surv. Neb., 253.)

This is the destructive species of California, and notwithstanding the fact that its wings are scarcely longer than its abdomen, yet it is able to sustain itself in the air for a considerable flight. I do not think it can fly any great distance, except with the wind, which bears it along. But it seems surprising that it should even be able to do this. Those who live in the east and have not seen a specimen of this species, can see it almost, if not exactly, represented in *Œ. pellucida* of Scudder; in fact, Mr. Scudder's description of this species agrees more exactly, if possible, with specimens from California submitted to me this season than his description of *atrox*. The only difference I can find between the two is that the median carina of the pronotum in *atrox* is severed by a transverse incision, while that of *pellucida* is entire. The examination of more specimens of the two species than I had before me may show that even this difference is not permanent. Had Mr. Scudder found individuals of the two species in the same locality, I do not think he would ever have thought of describing two species therefrom, yet that does not prove that he is in error, for the widely different habits and the widely separated localities at which they are found are sufficient to

indicate different species. May not two insects be exactly alike so far as external anatomy and coloration is concerned, and yet be specifically different? Certainly, there is nothing to forbid this conclusion. Although the perfect insects may be alike, yet the larvæ or pupæ may be different; the eggs, time of hatching, habits, sounds produced, &c., may indicate a difference which does not appear in the imagos. Specimens of this species were received at the Agricultural Department during the autumn of 1871, with an accompanying letter in regard to the injuries inflicted by it. The specimens I examined were communicated to me by Professor Glover.

Œ. collaris, Scudd., (Hayden's Geol. Surv. Neb., 250.)

I did not observe this species west of the mountains, but find it among my collection made in Colorado in 1869, also in the collection made by Mr. Dodge in Nebraska.

Œ. tenebrosn, Scudd., (Hayden's Geol. Surv. Neb., 251.)

Syn., *Tomonotus Mexicanus*, Thos., (Proc. Acad. Nat. Sci., Phila., 1870, 82.)

Pl. I, fig. 2.

Although I did not observe this species in the Salt Lake Basin, yet I traced it beyond the mountains in Wyoming to the Green River Valley. I also find it in the collection made by Mr. Dodge in Nebraska. After a thorough examination of a number of specimens, I think it is quite possible that the specimens I heretofore marked *T. nietanus* and *T. pseudo-nietanus* are but varieties of this species. The variations are considerable in the coloration, yet I find every intermediate shading. The dark border to the wings appears to be uniform and permanent, being the same in all the varieties; the flight and the shrill notes of the males appear to be the same; therefore, notwithstanding the variations in color and size, I am inclined to think they are all varieties of the same species.

Some of the specimens are pale ash-brown, uniformly dotted over with fuscous; others, especially the males, are nearly black; others have the entire disk of the pronotum a pale ash-yellow; while others have only the borders of the pronotum of this color. As the descriptions heretofore given are from alcoholic specimens, I give the following notes from my field-book in regard to the living insect: Face pale ash, dotted over very thickly with black points; mouth whitish; outer joints of the palpi white. Wings with the broad basal portion a clear orange-red; apex transparent, marginal band of black or dark fuscous. Posterior femora crossed on the outside with three pale bands, the one near the apex white and straight. Upper end of the posterior tibiæ black, then a narrow white band, the middle portion bluish-green; tarsi pale yellow. Central portion of the sternum greenish-yellow.

I am now inclined to think none of these varieties correspond with Saussure's *T. Mexicanus* or *T. nietanus*, but cannot say positively they do not.

Œ. carlingiana, Thos., (Proc. Acad. Nat. Sci. Phila., 1870, 81; Hayden's Geol. Surv. Terr., 1870, 275.)

I saw no specimens of this species west of the mountains, but when we crossed the range to the Atlantic side in Montana they again appeared.

Œ. undulata, nov. sp.

Middle foveola of the vertex somewhat elongate, elliptical, with a median carina through it, and generally a depression at the front at the top of the frontal costa; lateral foveolæ very shallow, small, triangular; the frontal costa expanding just above the ocellus and at the base, sulcate in the middle portion. Pronotum contracted on the anterior lobes, posterior lobe flat on the disk, rapidly expanding and punctured; median carina a dim line, slightly raised on the front lobe; apex right-angled. Elytra and wings passing the abdomen about one-third their length. Wings papilioform,* very broad, the exterior margin regularly and beautifully undulated or waved; anterior submarginal space almost as broad as the elytra; nervules prominent, regularly and remarkably parallel.

Color, (dried after a short immersion in alcohol.)—Ash-brown. Head and thorax sometimes mottled with darker brown or fuscous. Elytra marked with dusky spots presenting a basal group, an irregular middle band, those on the apical portion sporadic. Wings transparent, tinged with yellow at the base, the outer half transparent or slightly fuliginous; the inner margin of this portion generally forms an irregular somewhat dusky stripe, parallel with the body when the wing is fully expanded, not bending inward at the hind margin; sometimes the dusky portion is indicated only by dark nervules and nerves, those of the inner half always being yellowish-white. Posterior femora have two black spots inside; the inferior channel black, or chiefly occupied by two black spots; posterior tibiæ are probably bluish when the insect is living.

Dimensions.—♀, length, 1.05 inches; elytra, 1.12 inches; posterior femora, .54 inch; posterior tibiæ, .47 inch. ♂ nearly as large, with similar proportions.

I found this species in Colorado and Wyoming east of the mountains. I also find it among the collection made by Mr. Dodge in Colorado; but as it is not among his collections made in Nebraska or Kansas, and does not appear to have been in the collection made by Professor Hayden in Nebraska, it probably belongs nearer the mountains.

Œ. Haydenii, nov. sp.

Head and thorax somewhat wrinkled. Vertex rather narrow; central foveola somewhat elongate; margins prominent and sharp; open in front and continuous with the sulcus of the frontal costa; median carina distinct; frontal costa sulcate throughout its length, very narrow above the ocellus; eyes prominent, sub-globose. Antennæ rather longer than usual. Pronotum tricarinate; median carina distinct but not prominent; lateral carinæ distinct only on the posterior lobe; third transverse incision very distinct, nearly straight, cuts the median carina about the middle; the anterior lobes are covered with irregular raised lines, the posterior lobe with elongate tubercles; apex blunt, terminating in a right angle. Elytra and wings passing the abdomen, narrow. Posterior femora slender.

Color, (dried after immersion in alcohol.)—Dull clay-color, dotted with brown or fuscous. A transverse fuscous stripe in front between the eyes. A small fuscous spot about the middle of each side of the pronotum. Upper and lower margins of the elytra marked with small fus-

* This term is used to distinguish the butterfly form of the wing from those with regularly convex margins; in this form there is a slight re-entering of the margin a little behind the front; this applies to the general contour and not to the smaller scallops.

cous spots; the middle field nearly clear, a few minute pale dots only being visible. Wings, of the alcoholic specimens, a dull yellow at base, but when living this portion is red; beyond which a tolerably broad fuscous band crosses, narrowed in front and behind, curving round the posterior margin but not reaching the anal angle, a submarginal ray extends up the front nearly to the base; apex pellucid, with the nerves partly ocherous and partly dusky. Anterior and middle tarsi with two black annulations. Antennæ with alternate rings of yellow and fuscous.

Color of the living insect, as appears from the short field-note made in regard to it, is as follows: Wings red at the base; antennæ with alternate rings of brown and red; general color ash-gray, marked with fuscous dots and spots.

Dimensions.—♀, length, 1 inch; elytra, .87 inch; posterior femora, .54 inch; posterial tibiæ, .45 inch. ♂, length, .62 to .7 inch; elytra, .7 inch.

Found in Colorado and Wyoming. My attention was first called to this species a short distance above Fort Fetterman, on the North Platte, but I afterward found it among my collections made in Colorado.

Œ. Kiowa, nov. sp.

Of small size; head as *Œ. longipes*, Charp., of Europe; occiput ascending, the front part standing above the disk of the pronotum; vertex broad, transverse; central foveola very distinct, quadrilateral, opening in front by a short channel, which connects it with the sulcus of the frontal costa; lateral foveolæ distinct; frontal costa rather narrow, distinctly sulcate throughout its length; eyes very prominent, slightly oblong. Pronotum more than usually contracted, a little in advance of the middle, tricarinate; median carina distinct, but not very prominent, twice notched, posterior notch about the middle, the middle portion shortest; lateral carinæ distinct on the posterior lobe, indistinct on the others; apical angle slightly obtuse, but not blunt; disk somewhat rugose. Elytra and wings rather narrow, passing the abdomen.

Color, (dried after long immersion in alcohol.)—Dull clay-yellow, with fuscous dots and spots; occiput with two indistinct fuscous stripes; disk of the posterior lobe of the pronotum dusky brown in the center, margins yellow; there are, also, generally two dusky spots on each side of the pronotum, near the front margin. The elytra have three fuscous bands across them, the one nearest the apex generally more or less obliterated by the transparency of this part; the apex pellucid; wings pellucid; nerves of the anterior portion dusky, the rest ocherous. Posterior femora, with three indistinct brownish bands exteriorly, the inside black next the base, and a smaller spot of the same color near the apex, rest yellow; tibiæ dull yellow, (probably blue when living,) slightly dusky at the base and apex.

Dimensions.—♀, length, .87 inch; elytra equal the body; posterior femora, .53 inch; posterior tibiæ, .47 inch.

I have found this species only in Colorado, east of the mountains.

Œ. gracilis, nov. sp.

Male.—Small size; slender; vertex narrow; central foveola elongate, open in front, the sharp margins continuous with the likewise sharp margins of the narrow and deeply sulcate frontal costa. Pronotum tricarinate; the median carina slightly prominent, twice notched, the front portion the most elevated, the middle portion very short, tuberculiform; the posterior incision a little in advance of the middle; lateral

carinæ distinct; apex right-angled; antennæ slender, passing the pronotum; eye, sub-globose, prominent.

Color, (dried after immersion in alcohol.) Ash-gray, mottled with fuscous, which pervades nearly uniformly the head, thorax, and elytra; sometimes two yellowish stripes are more or less distinct on the disk of the pronotum, one along the inner side of each lateral carina. Wings pale transparent yellow next the base, (possibly pale red when living;) apical half dusky, the inner margin of this part darkest, forming a rather narrow, irregular band, which curves but slightly on the posterior margin, not reaching the anal angle; the apex clouded. The lower channel and inside of the posterior femora black, with a pale ring near the apex; antennæ fuscous, with yellow annulations.

Dimensions.—Length, .85 inch; elytra, .9 to .95 inch; posterior femora, .46 inch; posterior tibiæ, .4 inch.

Found in Colorado and Wyoming.

I have specimens which are probably females of this species, but as I am in doubt in regard to them I have not attempted to describe them as such.

Œ. Wyomingiana, nov. sp.

Very similar to *Œ. collaris*, Scudd., but differs in size, in the carvings of the vertex and in the distribution of the spots on the elytra.

Central foveola of the vertex slightly elongate; the sharp margins not quite meeting in front, but continuous with the sides of the frontal costa; frontal costa narrow, rather deeply sulcate, expanding below, reaching to the clypeus. Median carinæ of the pronotum prominent, sub-cristate, with a very narrow but deep notch or incision a little in advance of the middle, the notch directed obliquely upward and backward; the top of the median carinæ is slightly arcuate; anterior margin slightly angled, the posterior extremity terminating in an acute angle; lateral carinæ distinct. Antennæ reach a little beyond the thorax.

Color, (dried after immersion in alcohol.)—Dull clay-yellow, mottled and spotted with brown and fuscous. Face and sides of the head and pronotum minutely dotted with brown; two short brown stripes on each side of the pronotum reaching from the front to the third transverse incision. Elytra pale ashen-yellow, semi-transparent at the apex, with a broad stripe of fuscous dots and small spots along the middle field from the base to the apex; an indistinct pale line along the dorsal angle; the dorsal margin near the base is usually dotted with brown; the lower margin has some faint dots along it. Wings transparent yellow at the base; apical third transparent with dusky nerves; a moderately black band crosses between these two parts, its width about equal to one-fourth the length of the wing, curving round the hind margin to the anal angle; a short, blunt, fuscous ray extends along the front margin about one-third the distance toward the base. Hind femora clay-yellow, with two bands and the apex fuscous externally; internally it is black; hind tibiæ reddish.

Dimensions.—♀, length, 1 to 1.05 inches; elytra, 1 to 1.05 inches; posterior femora, .62 inch; posterior tibiæ, .54 inch. ♂, length, .8 inch; elytra, .85 inch.

Found only in Eastern Wyoming.

This may be but a variety of *Œ. collaris*, Scudd., and I have described it as new with some hesitancy on this account.

Œ. Montana, nov. sp.

Female.—In form and size much like *Œ. corallipes*, but a very distinct

species. Vertex broad; central foveola sub-quadrilateral, transverse, its interior surface more or less interrupted by small tubercles; the two lateral foveolæ distinct; tip depressed, sometimes forming two small foveolæ, but these are irregular, sometimes running into one and sometimes wanting. Frontal costa vertical, broad, expanding at the ocellus and at the base, more or less sulcate. Pronotum rugose, tuberculate, but not so rough as *Œ. Haldemannii.* Posterior femora rather short, and not so broad as in either of the two species just named.

Color, (dried after immersion in alcohol.)—Reddish-brown. Elytra brownish at the base, paler and semi-pellucid toward the apex, with dim, brown, cellular spots scattered somewhat equally over it, growing paler and dimmer toward the apex; in some specimens these spots are almost, and in others quite, obsolete; in some cases they are quite distinct, somewhat fuscous and partially run together. The wings are pale red at base, (but when living they are of a bright red;) a narrow, somewhat broken, cellular, dark band crosses beyond the middle, curving round the posterior margin, decreasing rapidly; it does not quite reach the anal angle; a broad ray of the same color runs up the front margin to the base. Posterior femora dull yellow, with no distinct bands.

Dimensions.—Length, 1.4 to 1.6 inches; elytra, 1.25 to 1.3 inches; posterior femora, .7 to .75 inch; posterior tibiæ, .62 inch.

Found in the upper part of Snake River Plain, near the mountain, and in Southern Montana. I do not know where I first met with this species as we moved northward, because for some time I supposed it was the same as that before noticed under the name of *Œ. paradoxa*, Thos., and therefore did not examine it closely; so it is possible that I did not obtain any specimens until I reached the mountains; but I am quite confident I did not meet with it south of Market Lake, and that I did meet with it on the north (Atlantic) slope of the range, and from there to Virginia City in Montana.

Œ. longipennis, nov. sp.

Elytra and wings longer than the body; the elytra spotted; the wings black or dark fuliginous at the base.

Male.—The vertex not very broad; central foveola elongate elliptical, with a slight median raised line, and open in front; frontal costa rather narrow, slightly expanded at the ocellus, sulcate, not expanding below. Median carina of the pronotum prominent, sub-cristate, as in *Œ. Carolina*, cut near the middle by the posterior transverse incision, each part arcuate; anterior margin somewhat angled, and extending slightly on the occiput; the posterior extremity acutely and rather sharply angled; the disk of the posterior lobe smooth and apparently without punctures. The elytra narrow, remarkably straight, the margins parallel; longer than the entire body. Wings about the same length, and broad. The posterior femora not channeled beneath. The cerci rather long, subcylindrical, and terrete. Antennæ passing the thorax.

Color, (dried after long immersion in alcohol.)—Reddish yellow. The head and pronotum, especially the dorsal portions, pale reddish, dotted with pale brown. The basal portion of the elytra reddish-yellow, the apical portion pellucid; marked throughout with dark brown spots somewhat in the form of bands. The wings for a very small space around the immediate base are transparent yellow; a triangular space at the apex extending inward about one-third of the way to the base pellucid, sprinkled at the immediate apex with fuscous dots; the posterior margin has a narrow pellucid rim; the rest is of a dark fuliginous color, which, when the wing is fully spread, appears like a very broad

band across the basal two-thirds, with its outer border parallel to the body. The posterior femora have two oblique brownish bands on the external face; within are two black bands; apex black internally. Venter and pectus dull yellowish-white. Antennæ pale at base; apical portion dusky.

Dimensions.—Length, 1.14 inches; elytra, 1.25 inches; posterior femora, .64 inch; posterior tibiæ, .55 inch.

Found among the collections submitted to me from the Agricultural Department, marked Kansas, which, from the other specimens, I suppose to be correct. The species is somewhat remarkable, and quite different from any other one belonging to the United States which I have seen. The dark wing would appear to bring it near *Carolina* and *Carlingiana*, but while it approaches the former in its slender form, it is nevertheless very distinct. I have never met with it at any point in the West, nor have I seen it in any other western collection. On this account, added to that of its semi-tropical *look*, (this word conveys my idea better than a long sentence,) I am inclined to believe it is a southern species, and may be found in the Indian Territory or Texas.

Œ. cincta, Thos.

(Proc. Acad. Nat. Sci. Phil., 1870, 70; Hayden's Geol. Surv. Terr., 1870, 275.)

As the description I gave of this species appears to have been from a variety not common, I give again a description in full from a number of specimens.

Somewhat like *Œ. eucerata*, Harr., but invariably larger. Head large, front of the occiput elevated; vertex broad, much deflexed; central foveola sub-quadrilateral, transverse in the female, but narrower in the male, opening in front into the sulcus of the frontal costa; the frontal costa of moderate width, sulcate throughout, expanding slightly at the ocellus. Eyes slightly oblong, sub-globose, prominent. Antennæ slender, passing the thorax. The pronotum has the median carina distinct, not prominent on the posterior lobe, slightly prominent on the anterior lobes, notched twice, middle part very short, the posterior transverse incision about the middle, front margin slightly angled, apical angle a little more than a right angle. Elytra and wings about as long as the body.

Color, (dried after immersion in alcohol.)—Clay-yellow, varied with brown and fuscous. Lower portion of the face, the cheeks, and lower margins of the sides of the pronotum pale yellow; two or three rows of brown dots on the occiput; a broad stripe along the middle of the pronotum, brown. The male generally has two oblique brownish stripes on the sides of the head and pronotum, the upper one embracing the lower portion of the eye. The elytra have the upper half and apical third sprinkled with small fuscous spots; on the lower half there are two broad fuscous bands, behind each of which there is a pale yellow immaculate space. Wings pale transparent yellow at the base, (color when living, unknown, but presume it is yellow;) a moderately broad fuscous band crosses just beyond the middle, curving abruptly upon the posterior margin to the anal angle; tip more or less clouded, rest of the apical portion pellucid, nervules pale yellow, (tip of the male, fuscous.) Posterior femora, with two or three dim oblique bands exteriorly, inside blackish next the base, a pale ring near the apex.

Dimensions.—♀, length, 1 inch; elytra, 1 inch; posterior femora, .55 inch; posterior tibiæ, .5 inch. ♂, length, .75 inch.

Found near the Platte Rivers, in Colorado and Wyoming.

STENOBOTHRUS, Fisch.

I have as yet observed but one new species of this genus among my collections, yet there may be more, as I have not yet examined them fully

S. bicolor, nov. sp.

Lateral foveolæ wanting. Face oblique. Three yellow and two brown stripes, reaching from the vertex to the apex of the elytra.

Vertex scarcely expanding in front of the eyes; margins elevated, obtuse; median line or carina distinct; the tip obtusely rounded. Frontal costa broad, expanding below, not sulcate, but slightly depressed at the ocellus. Lateral carinæ prominent and diverging rapidly. Each side of the face, between the middle and lateral carinæ, has an irregular curved impression. Eyes ovate, placed well forward. The head seen from above is slightly broader than the thorax, and tapers to the vertex. The pronotum is the same length as the head; truncate in front, obtusely rounded behind; sub-cylindrical, faintly tricarinate, the three carinæ being close together, parallel (though in some specimens the lateral carinæ are slightly bent inward near the middle;) the posterior transverse incision only cuts the carinæ, and is situated behind the middle. The antennæ somewhat flattened, not longer than the head and thorax, about twenty joints. Elytra narrow, as long as the abdomen; wings nearly same length. Abdominal appendages very short, the upper valves of the ovipositor not passing beyond the last segment. The posterior femora reach the tip of the abdomen.

Color, (dried after long immersion in alcohol.)—Parts of the mouth, venter, and sternum pale yellow. Face dull yellow. Eyes ash-brown. Two very regular brown stripes starting from the vertex, (one from each side near the upper angle of the eye,) gradually enlarging, run along the sides of the head and pronotum, continuing along the angle of the elytra their entire length; between them extending along the middle of the head, pronotum, and suture of the elytra is a yellow stripe about the same width as the brown ones are; below each brown stripe, on the side, is another broad yellow stripe, which is narrowed near the extremity of the abdomen. In other words, the color is yellow, with two broad brown stripes extending along the upper part of the sides. An obscure brownish band extends obliquely back behind each eye to the pronotum; and a more distinct stripe of the same color marks the lower part of the sides of the pronotum, generally bordered by narrow but distinct yellow lines. Wings pellucid, the nervules near the apex dusky, the rest ocherous. Posterior femora crossed inside by three dark brown or black bands; externally, there are three brown spots on the upper part of the disk. When living the posterior tibiæ are blue, but after long immersion in alcohol they are dull yellow; spines black at the tip. Anterior legs pale brown. The brown markings of this species are often tinged with a lilac shade.

Dimensions.—♀, length, .81 inch.; elytra, .64 inch.; posterior femora, .51 inch.

Found in Colorado and Wyoming, east of the mountains, where it is quite common. The colors after immersion in alcohol differ very little from what they are when living, except the blue of the tibiæ. This species approaches very near to *Epacromia*, and is closely allied to *S. epacromoides*, Walk.

Var. *a*.—The median or dorsal stripe brownish, which, uniting with the lateral stripes, gives the entire back a brownish color; the posterior

femora striped with brown. This variety was found near Fort Fetterman, on Platte River.

OXYCORYPHUS, Fisch.

Division I.

Tip of the vertex sub-acute. Pronotum not constricted; posterior extremity obtuse-angled; the transverse sulcus situated behind the middle; lateral carinæ acute, equal throughout. (Sauss., Rev. et Mag. Zool., XIII, 1861, 314.)

Ox. obscurus, nov. sp.

Female.—Head conical; occiput ascending, the vertex ascending in the same line with it, convex with a slight median carina, most distinct in front; the margins of the vertex slightly elevated, obtuse, and terminating behind at the upper canthus of the eyes; the vertex sub-conical, tip glabrous. Face quite oblique, nearly straight; frontal costa sulcate, parallel to ocellus, below which it gradually and regularly expands; lateral carinæ distinct, sharp, curving slightly forward at the top in front of the eyes, nearly straight, and rapidly diverging below. Antennæ ensiform, flattened, a little longer than the head; joints short. Eyes elongate pyriform, acuminate above, oblique. Pronotum a little longer than the head; tricarinate, the carinæ equal, distinct, and parallel; sides compressed, perpendicular; sub-truncate in front; posterior margin obtuse-angled; transverse incision behind the middle; posterior lobe thickly covered with shallow punctures; the posterior lateral angle is a right angle. The elytra narrow, about three-fourths as long as the abdomen. Wings nearly as long as the elytra. The abdomen carined; valves of the ovipositor obtuse, hairy on the margins, the upper ones strongly curved. The legs slender; the femora compressed; posterior femora nearly as long as the abdomen.

Color, (dried after long immersion in alcohol.)—Pale rufous. Elytra semi-transparent toward the apex. Wings pellucid, with pale rufous nerves.

Dimensions.—Length, .93 inch; elytra, .5 inch; posterior femora, .5 inch; posterior tibiæ, .42 inch.

Wyoming Territory. I am uncertain as to the exact point where the two specimens collected were found.

LIST OF SPECIES OF BUTTERFLIES COLLECTED BY CAMPBELL CARRINGTON AND WILLIAM B. LOGAN, OF THE EXPEDITION, IN 1871.

BY W. H. EDWARDS.

Papilio rutulus, Boisduval.—Junction.
turnus, Linn.—Montana.
Parnassius smintheus, Doubleday.—Junction; Yellowstone.
clodius, Menetus.—Montana.
Pinis protodin, Bois.—Several localities.
Anthocaris ansonoides, Bois.—Hot Springs.
Colias enegthenu, Bois.—Virginia City and several localities.
philodin, Godart.—Hot Springs.
alexandra, Edwards.—Yellowstone.

Colias astræa, Edwards.—Colorado.
Argynnis edwardsii, Reakirt.—Junction and several localities.
montivaga, Behr.—Yellowstone.
meadii, Edwards.—Colorado.
myrina, Cramer.—Colorado.
Meletæa hoffmanii, Behr.—Junction.
Phyciodes tharos, Bois.
Grapta satyrus, Edw.—Hot Springs.
Pyrameis huntera, Drury.—Montana.
Vanessa antiopa, Linn.—Montana.
melbertii, Godart.—Bozeman City.
Cœnonympha ochracea, Edw.—Virginia City.
Erebia rhodia, Edw.—Yellowstone.
haydenii, Edw., new species.—Yellowstone.
Satyrus nephele, Kirby.—Yellowstone.
silvestris, Edw.—Virginia City.
sthenele, Bois.—Virginia City.
Chrysophanus rubidus, Edw.—Stinking Creek.
Lycæna anna, Edw.—Pleasant Valley.
acmon, Bois.—Meadow River.
Pyrgus syrichtus, Fab.—Montana.
Herpena comma, Linn.—Virginia City.

In addition to the above were several specimens, especially of *Lycænidæ*, that were too much injured for recognition.

W. H. EDWARDS,
Coalburgh, West Virginia.

JANUARY, 1872.

EREBIA HAYDENII, Edwards, new species.

Male: expanse, 1.6 inches.

Upper side fuscous, immaculate; under side a shade paler, much irrorated with gray scales; primaries immaculate; secondaries have a complete series of black ocelli along the edge of hind margin, one in each interspace; each ocellus narrowly ringed with ochraceous, and having minute white pupil.

REPORT ON THE RECENT REPTILES AND FISHES OF THE SURVEY, COLLECTED BY CAMPBELL CARRINGTON AND C. M. DAWES.

BY EDWARD D. COPE, A. M.

REPTILIA.

OPHIDIA.

CAUDISONA CONFLUENTA, Say; *var.* with transverse spots narrowed.

Ogden, Utah.

EUTÆNIA VAGRANS, B. and G., (Catalogue, p. 35.)

Fish Creek, Montana; Yellowstone Basin; between Copenhagen, Utah, and Fort Hall, Idaho; Fort Hall, Idaho; Salt Lake City; Ogden, Utah.

Var. a. With colors like *E. sirtalis;* the sides olive, with about fifty pairs of black spots, the vertebral band yellow, black-bordered. From Camp Carling.

EUTÆNIA PARIETALIS, Say.

Salt Lake City; lake ten miles east of Logan, Utah, (salt;) Fish Creek, Montana.

PITYOPHIS BELLONA, B. and G.

One specimen without the anterior frontal (vertical) shield; from Ogden, Utah.

BASCANIUM FLAVIVENTRIS, Say, (B. and G., Catalogue, p. 96.)

Ogden, Utah.

LACERTILIA.

PHRYNOSOMA DOUGLASSII, Bell.

Var. α.—The usual form; Salt Lake City.

Var. β, *exilis.*—A small form not more than one-half or two-thirds the usual size, but nearly identical in details of structure and coloration.

The differences observable are: the rather shorter muzzle, which is entirely vertical in profile; the smaller scale above the canthus of the mouth, and the temporal horns; the less prominence of the posterior superciliary angle, and the much reduced size. A geographical variety. Carrington's Lake, Montana; Fort Hall, Idaho.

SCELOPORUS CONSOBRINUS, B. and G.

This species is very abundant and variable. Its varieties are four, as follows:

Var. 1.—Typical; scales large, especially on the sides; crural cross-series, 10–11; rows between interscapular and crural points, 33; 2 prefrontals on each side; lateral and dorsal spots distinct. Localities, Yellowstone Basin; Blackfoot Fork.

Var. 2.—Like the last, but the scales smaller on sides and back; 13 rows on rump. Salt Lake City, Utah; south of Fort Hall, Idaho.

Var. 3.—Scales still smaller; 16–17 interscapular, 14 crural cross-rows; 3 prefrontal plates on each side. Dorsal spots large, their borders touching the lateral spots; both pale-edged behind, forming an angular border in ♀. This form grades into the last. A male has the border color of variety 2. South of Fort Hall, Idaho.

Var. 4.—Like variety 2, but only half the size. South of Fort Hall, Idaho, and Salt Lake City.

SCELOPORUS GRACIOSUS, B. and G.; *S. gracilis*, B. and G.

This species is very near the last, but the scales are still smaller. There are 38 transverse dorsal rows and 20 interscapular. The lateral scales are twice emarginate. From Salt Lake, Utah, to Oregon.

CNEMIDOPHORUS TESSELLATUS, Baird; *Amiva tessellata*, Say, (*vide* Pac. R. R. Surv., vol. X, Beckwith's Report.)

Salt Lake, Utah.

TESTUDINATA.

CHRYSEMYS OREGONENSIS, Harlan; Agass.

The Yellowstone Lake.

BATRACHIA.

ANURA.

BUFO COLUMBIENSIS, B. and G., (United States Exploring Expedition, Herpetology, by Girard, p. 77.)

Pleasant Valley and Yellowstone Basin. Specimen from latter local-

ity like types; that from Montana different in coloration. It is a bright green, with numerous blackish speckles on upper surfaces, and brown interscapular spots; below uniform.

CHOROPHILUS TRISERIATUS, Wied; *Helœcetes*, Baird.

Carrington's Lake, Yellowstone Basin.

SPEA BOMBIFRONS, Cope.

Blackfoot Fork.

RANA HALECINA, Bosc.

Fort Hall, Idaho.

RANA PRETIOSA, B. and G., (United States Exploring Expedition; Herpetology, p. 20.)

Pleasant Valley, Montana.

This frog is a near ally of the European *R. temporaria*, and is, as Girard remarks, distinguished from the other west-coast species (*R. aurora*, B. and G.) by its much shorter limbs. The present species was originally found at Puget's Sound, Washington Territory.

RANA SEPTENTRIONALIS, Baird, (Proc. Acad. Nat. Sci., Phila., 1854, 61.)

Abundant; Carrington's Lake, Yellowstone Basin, and Fish Creek, Montana.

PISCES.

ISOSPONDYLI.

COREGONUS VILLIAMSONII, Girard; the Rocky Mountain white fish.

THYMALLUS TRICOLOR, Cope, (Proc. Acad. Nat. Sci., Phila., 1865, p. 80; Gunther, Catalogue Brit. Mus., VI, 201.)

Specimens from Yellow Creek and the Gallatin Fork of the Missouri in Montana. This species was originally discovered in the Grand River, Michigan. It seems to be a rare fish east of the Mississippi; but my friend, J. Dickinson Sergeant, informs me that it has been found abundantly in a stream in the northern part of the peninsula of Michigan. The number of specimens brought by Dr. Hayden from the head-waters of the Yellowstone indicates that this region is its home. They maintain well the characters by which it was originally distinguished from the *T. vulgaris* and *T. signifer*. The muzzle is shorter and the gape of the mouth larger than in the former; the maxillary bone is narrower and longer, reaching to below the middle of the pupil instead of to near the front of the orbit. The length of the head equals the depth of the body and enters the length without caudal fin, 4.5 times. There is some variation in the radial formula as follows: D. 20–22; A. 13–14. Scales, 8–9—86–90—10–12. In the younger specimens the small blue spots tend to form short longitudinal bars.

SALMO, Linn.

The species of this genus, found in the streams rising in the Rocky Mountains, are numerous, and, as elsewhere, nearly allied. Those I have observed in Dr. Hayden's collections number three, while a fourth is described by Dr. C. Girard, which I have not met with. The allied species differ as follows. They all belong to the group *Salar*:

Depth, 5.75 in length; eye, 4.5 times in head; snout obtuse; caudal fin scarcely emarginate; Br. IX............... *S. virginalis.*

Depth, 4.75 in total, (to point caudal;) eye, 5 times in head; muzzle acute; scales larger, 26 below dorsal fin; cranium not keeled above; head one-fourth length; dorsal fin nearer muzzle than end caudal scales; caudal fin scarcely emarginate; Br. X .... *S. spilurus.*

Head large, broad, flat, not keeled, 4.25 in total, equal depth of body; muzzle obtuse; eye nearly 5 times in head; scales, 42 below dorsal first ray; dorsal fin equidistant; caudal fin not notched .... *S. stomias.*

Head smaller, 4 times in length to notch of caudal, (which is well emarginate;) upper surface keeled; muzzle obtuse; eye 4 times in length; depth, 4.5 in length, to end caudal scales; dorsal midway between latter and end of muzzle; scales small, 40–43 below dorsal first ray; Br. XI .... *S. pleuriticus.*

Head acuminate, keeled above, 4.66 times in length to notch of caudal fin, which is well marked; eye, one-fifth head; depth, 5.25 to caudal notch; dorsal nearer muzzle than end of caudal scales; scales large, 33 below dorsal first ray; Br. XII; spots large, distant .... *S. carinatus.*

Head one-fourth total length; eye, 5 times in head; dorsal fin equidistant between insertion of caudal and end of muzzle; muzzle rather pointed; Br. X, XI .... *S. irideus.*

Of the above species *Salmo spilurus* and *S. carinatus* are distinguishable by their large scales and smaller orbits; while in *S. stomias* and *S. pleuriticus* the scales are very small. On the other hand, *S. carinatus* and *S. pleuriticus* agree in the strong median carina on the superior aspect of the cranium. *S. stomias* is readily separated by the large head and mouth. Its habitat, so far as known, is the Kansas River, far to the eastward of the Rocky Mountains.*

SALMO SPILURUS, Cope, *sp. nov.*

This species is represented by six specimens from the Sangre de Christo Pass, in Colorado, from one of the sources of the Rio Grande.

It is rather a fusiform fish, with small head and acuminate muzzle, which is very little decurved at the end to the lip margin. The eye enters the muzzle 1.33 times, the inner border of the adipose eyelid being regarded as the dividing line. The top of the head is slightly convex, but entirely without keel. The maxillary bone extends to a little beyond the posterior margin of the orbit, and is flat and considerably wider distally than it is proximally. In this it differs from the *S. stomias*, Cope, where that bone maintains an almost equal width throughout. All the teeth are well developed, including both rows of vomerines. Scales in about 33 rows between the base of the first dorsal ray and the lateral line, or 26 rows between the middle of the dorsal fin and the same.

Radii, Br. X; D. II. 11, (10 in one;) A. II. 10, (in two, 11.)

Ground color, pale in spirits; the caudal peduncle from the middle of the anal fin, with the caudal and dorsal fins, thickly spotted with large, irregularly disposed black spots. Those on the caudal peduncle are darkest between the scales; each one having, therefore, a reticulated appearance. Above the lateral line they extend to the dorsal fin, continually contracting their distribution from the lateral line upward.

* In Hayden's Report, Geology of Wyoming, 1871, p. 433, this is erroneously stated to be the Platte, a very different river.

A few scattered spots are found all the way to the head, and four or five mark the side of the latter. Adipose fin spotted; others unicolor.

The largest specimen obtained measures 13 inches in length.

The affinities of this species to the *S. virginalis* appeared to be close, and Girard cites specimens from the locality from which it was procured as belonging to the latter. Its description cannot, however, be reconciled with the *S. spilurus*, especially in the relations of the depth to the length, by which it would appear that *S. virginalis* is a much more slender fish. The figure also agrees with the description.

SALMO PLEURITICUS, Cope, *sp. nov.; Salmo* (*Salar*) *virginalis*, Cope, not Girard, (Hayden's Survey Wyoming, 1871, 433.)

This is the abundant mountain trout of the head-waters of the Green and Platte Rivers, and even of the Yellowstone. It is rather a stout species, with obtusely descending muzzle, and large eye entering the head only four times. The cranial keel is a marked character; its elevation is greater between the orbits than on the posterior part of the frontal bones. The interorbital width is 1.33 times the long diameter of the interpalpebral opening of the eye. The dorsal fin is nearer the origin of the marginal rays of the caudal fin than to the end of the muzzle, but is midway between the latter and the termination of the scales on the sides of the fin. Radii, D. II. 11–12 and 13; A. II. 11. Br. XI. The scales range from 40 to 45 below the first dorsal ray to the lateral line. The maxillary bone extends to a little beyond the orbit, and is not expanded.

This is a spotted species, and the spots are chiefly found above the lateral line and on the whole caudal peduncle, and on the dorsal and caudal fins. They are usually rather scattered, less numerous on the peduncle than in *S. spilurus*, and more so anteriorly; those on the fins are smaller and less numerous. There is, however, variation in the size and number of the spots. The sides are ornamented with short, broad longitudinal bars of crimson; a band of the same color occupies the fissure within each ramus of the mandible and skin on the median side of it. The fins are all more or less crimson; but none of these are black-bordered. The largest specimens are 10–12 inches long.

Seven specimens of this species are in the collections from the heads of Green River; from Medicine Lodge Creek, Idaho, (two specimens;) four from the Junction, Montana. A specimen each from Yellow Creek and the Gallatin Fork of the Missouri, Montana, represent at least a color variety of this fish. The spots are much smaller and much more numerous, though distributed over the same regions; they are less numerous on the caudal fin. In the Gallatin specimen there are 51 scales above the lateral line; in the other 44. Another variety from the Yellowstone Basin is only represented by young specimens. They have no spots on the caudal fin.

A number of dried specimens from the Yellowstone Lake, of larger size than the specimens above described, probably belong to this species. They are rather more closely spotted on the caudal peduncle and fin, but are similar in all important respects. The only discrepancy which I find is the relatively smaller eye, (not orbit,) which enters the head five times, and the greater prolongation of the maxillary bone. These characters are, perhaps, due to the larger size attained by the individuals. They are from a foot to eighteen inches in length.

SALMO CARINATUS, Cope, *sp. nov.*

The characters of this species, pointed out in the table, show its marked

distinction. It is a more slender fish than any here described, approaching more nearly the proportions assigned by Girard to the *S. virginalis*. From this species the numerous branchiostegals, more distinctly forked tail, &c., distinguish it.

The head is elongate, but not wide, and the muzzle descends regularly, but not abruptly, to the lip margin. The eye is contained in it 1.5 times and enters the head five times in a specimen of the size of those of *S. pleuriticus*, where it enters four times, as well as in larger animals. The interorbital region contracts at the front part of the orbits so as to be little wider than the long diameter of the latter. The frontal keel extends the whole length of the vertex, and is very conspicuous; it is most elevated posteriorly. The maxillary extends to beyond the orbit. The dorsal fin is equidistant between the end of the muzzle and the base of the marginal radii of the caudal fin, therefore nearer the former than to the termination of the lateral caudal scales.

Radii, Br. XII, XI; D. II–11; A. II–11.

The ground is light, perhaps rosy in life, and is marked with round, black spots, sparsely but equidistantly distributed over the whole body. The dorsal and caudal fins are spotted, but rather sparsely; those of the former being arranged in two or more longitudinal series. There are indications that the fins and sides of the head were crimson, and that there were large spots of the same color on the middle of the sides.

Two specimens of uncertain locality; fragments of, perhaps, a third from the Yellowstone Geyser Basin.

Another species of trout was obtained from Carrington's Lake, Montana, but the specimens are in too bad a state for determination.

PLECTOSPONDYLI.

SEMOTILUS CORPORALIS, Mitch.

Crow Creek, at Camp Carling.

CERATICHTHYS NUBILUS, G.; *Argyreus nubilus*, G., (U. S. Pac. R. R. Surv., X, p. 244.)

This species has the physiognomy of the genus to which Girard referred it, but the premaxillary is projectile and the upper lip separated from the muzzle by a fold. This is the only point of distinction yet stated by which the two genera may be separated. Teeth, 4.2–2.4; barbels inconspicuous. Axils of the fins crimson.

Grass Creek, Idaho. Collection No. 4.

APOCOPE, Cope, *gen. nov.*

Teeth of the raptorial type, 4.1–1.4, without grinding surface. Barbels present; upper lip separated from muzzle by a fold. Anterior part of the lateral line only present.

APOCOPE CARRINGTONII, Cope, *sp. nov.*

This is a small species allied to the last, but the muzzle is broader and less prominent, and the mouth larger. The muzzle is quite obtuse in profile and overhangs the mouth very little, and the end of the maxillary bone does not quite reach the line of the margin of the orbit. Barbels minute; teeth, 4.1–1.4; isthmus wide; eye a little smaller than one-fourth the length of the head, and 1.5 times in interorbital width. Scales, 10–60–11. Dorsal fin originating behind the point above the ventrals, and markedly nearer the basis of the caudal than the end of the

muzzle. Caudal well forked. Radii, D. 8; A. 7; length of head a little more than four times in length to basis of caudal; depth five times in the same; length, 20 lines.

Color olivaceous, with a dark lateral band from end of muzzle, and dark shades on the back.

Four specimens from the Warm Springs, Utah. The species is named in honor of Campbell Carrington, zoologist of Dr. Hayden's expedition, to whose zeal in the cause of science we are indebted for the materials analyzed in this report, and that on the same subject in the Survey of Wyoming, 1871. Collection No. 9.

APOCOPE VULNERATA, Cope, *sp. nov.*

The head is broad and the muzzle wide and obtuse, not projecting over the mouth. Barbels minute. The end of the maxillary bone does not quite reach the marginal line of the orbit; orbit five times in head, one and a half times in the interorbital space. Length of head one-fourth, depth of body one-fifth length without caudal fin. Dorsal a little behind line of origin of ventrals, nearer caudal fin than muzzle. Radii, D. 8; A. 7. Length, 24 lines. Scales small, 15–72–10.

Color olive, with a broad dark band from end of muzzle to caudal fin, paler above and below it; belly yellow; a crimson spot on the chin.

This species differs from *A. carringtonii* in the wider muzzle, smaller scales, and greater development of the lateral line. In this species it is continued to the end of the anal fin; in the type of the genus it scarcely extends to the dorsal. Collection No. 1.

From Logan, Utah; discovered by Cam. Carrington.

RHINICHTHYS MAXILLOSUS, Cope, (Proc. Acad. Nat. Sci., Phila., 1864, 278.)

Crow Creek; Grass Creek, Idaho.

TIGOMA RHINICHTHYOIDES, Cope, *sp. nov.*

Size small; form elongate. Head 4.3 times in length without caudal fin; depth, 5.2 times in same. Muzzle obtuse, not projecting; mouth inferior horizontal, maxillary not reaching line of orbit. Head nearly four times longer than diameter of orbit, which equals length of muzzle, and is 1.5 times interorbital space. Teeth, 4.2–2.4. Scales, 12–67–12, lateral line with occasional interruptions at the posterior part. Dorsal fin behind line of ventrals, nearer basis of caudal fin than end of muzzle. Length, 24 lines.

Olive-brown above, yellow below; a broad brown lateral band and longitudinal blackish line on the thoracic region on each side. The median band is darker spotted, and there are blackish spots on the dorsal region. Head black above; chin red.

The upper lip of this species is separated by a fold, but the species has a general resemblance to those of *Rhinichthys*.

From Logan, Utah. Collection No. 2.

PROTOPORUS, Cope, *gen. nov.*

Teeth raptorial; outer row, 4–4; no grinding surface; no barbels; upper lip separated by a fold. Lateral line represented only by a short anterior series of pores.

This genus is related to *Tigoma*, as *Apocope* is to *Ceratichthys*.

PROTOPORUS DOMNINUS, Cope, *sp. nov.*

Form rather stout, front convex, muzzle obtuse, mouth horizontal, end of maxillary not quite attaining orbit. Scales, 9–56–6. Lateral line not

attaining the point opposite to the origin of the ventral fins. Length of head, 4.33; depth of body five times into length without caudal fin; diameter of eye four times in head; once in muzzle, 1.3 times in interorbital width. Fin radii, D. I. 8; A. I. 7. Rays of pectoral thickened, not reaching ventral; ventral reaching anal. Length, 24 lines; teeth, 4.2–1.4, somewhat hooked.

Color silver-gray, with a broad dark lateral band, which is darker spotted; back and sides of thorax dark shaded; top of head dark.

Numerous specimens from Fort Hall, Idaho, collection No. 3.

HYBOPSIS BIVITTATUS, Cope, *sp. nov.*

Muzzle narrow, very obtusely descending, not projecting; mouth horizontal, end of maxilla reaching the line of the orbit. Orbit four times in length of head, 1.5 times in the rather flat interorbital width. Length of head, 4.66 times; depth of body four times in length minus caudal fin. Dorsal region arched; basis of dorsal fin descending posteriorly, and originating very little behind origin of ventrals. Pectorals only reaching half-way to ventrals; latter about half-way to anal. Radii, D. I. 8; A. I. 7. Teeth, 4.2–2.4, with grinding surface. Scales, 12–53–11. Lateral line complete. Dorsal fin nearer muzzle than origin; caudal fin midway between former and notch of latter. Length, 3 inches.

Color silvery; the scales blackish punctulate; dorsal region blackish; a dark band from epiclavicular region to basis of caudal fin; another from end muzzle, across operculum, to basis of anal.

From Warm Springs, Utah; Campbell Carrington, collector. Collection No. 10.

It is interesting to note that in the distribution of color, especially in the two lateral bands, this species is identical with *Protoporus domninus*, *Tigoma rhinichthyoides*, and *Apocope carringtonii*, a well-marked case of mimetic analogy. Another case of this kind is exhibited by two species of eels of different genera from Costa Rica. The species are undescribed.

MURÆNA AQUÆDULCIS, Cope, *sp. nov.*

Branchial fissure small; posterior nostril not tubular, situated half-way between eye and anterior nostril. Eye contained nearly twice in the muzzle. Maxillary teeth in two rows, ethmoids in a single one. Former, 4 long in the inner, 17 in the outer row, counting from the front margin of the orbit. Vomerine teeth well developed; dentaries in two rows.

Form stout; dorsal fin extending two-thirds the total length, the anal 2.33 times in the length. Color brownish-black, with rather distant yellow spots, which are accompanied by a darker shade on same side, and which become confluent into yellow marblings on the gular and pectoral regions.

From the Rio Grande, near the city of San José, Costa Rica, Central America.

PŒCILOPHIS NOCTURNUS, Cope, *sp. nov.*

Branchial fissure small; posterior nostril just above the orbit at the anterior margin. Muzzle rather obtuse, twice as long as the small eye. Maxillary teeth in a single row; the vomerines obtuse, continued in line to the ethmoids. Latter in three rows, with interspaces. Dentaries one-rowed. Form moderately stout; dorsal fin extending nearly to nape. Anal fin a little over one-third total length.

Color deep purplish-brown, with rather scattered, irregular, yellow spots with black margins; rather paler below.

From the Rio Grande, at San José, Costa Rica. Dr. Van Patten.

This species, in general proportions, is a little more slender than the last, but in general appearance, as size and coloration, can scarcely be distinguished from it. It is a curious case of mimetic analogy.

SIBOMA ATRARIA, G., (U. S. Pac. R. R., Rep. X, 297.)

Abundant in Grass Creek, Idaho. *Siboma* differs from *Clinostomus* in the anterior position of the dorsal fin. Collection No. 7.

MYLOLEUCUS, Cope, *gen. nov.*

Teeth raptorial, but with well-developed masticatory surface, 5–4 in outer row. No barbels; lateral line well developed. Dorsal fin above or in front of line of ventrals.

This genus is *Siboma*, with developed grinding surfaces of the teeth.

MYLOLEUCUS PULVERULENTUS, Cope, *sp. nov.*

Form stout; head short, muzzle not decurved; mouth terminal, slightly descending, the maxillary bone nearly attaining the anterior line of the orbit. Head 3.75 times in length, exclusive of caudal; depth three and a half times. Eye 4.2 times in head, once in muzzle. Preorbital bone deeper than long. Scales, 13–58–9. Radii, D. I. 9; A. II. 7. Caudal well forked. Length, 3½ inches.

A dark plumbeous band extends from the origin of the lateral line above to the caudal peduncle, and on it to the caudal fin. Below this the color is silvery, thickly dusted with black dots; above it is an olive-yellow band; then a dark dorsal region, all dusted. Sides of head silvery, dusted. Fins unspotted.

Numerous specimens from the Warm Springs, Utah; type No. 6.

CLINOSTOMUS PANDORA Cope, *sp. nov.*

This species is nearly a *Siboma*, in consequence of the position of the dorsal fin being so little removed from the vertical above the ventrals. Dentition refers it to *Clinostomus*, while its appearance is that of a *Ceratichthys* or *Semotilus*. I adhere to the technical characters until others are found which will give us the clew to the truer affinities.

Shape fusiform, head small, one-fifth of total length, (or fourth without caudal fin,) broad, and rather flat at the muzzle. The latter does not project, and the lips are equal. Maxilla not attaining the line of the orbit by some distance. Eye small, 6.25 times in length of head, twice interorbital width. Scales, 17–61–9, small in front of dorsal fin. Radii, D. I. 8; A. II. 8. Isthmus moderately wide; depth of body 4.2 times in length without caudal. Dorsal fin nearer basis caudal than end of muzzle.

General color silvery, above (in spirits) brownish. A broad, ill-defined, lateral band, from epiclavicular region to basis of caudal fin, above the lateral line. Length of type specimen, 8 inches. Collection No. 11.

From Sangre de Christo Pass, from a tributary of the Rio Grande.

CLINOSTOMUS HYDROPHLOX, Cope, *sp. nov.*

This species and the following are typical forms of the genus, and interesting as the first that have been detected west of the Mississippi River. Length of head 4.75 times in total, exclusive of caudal fin; depth of body 4.5 times in same. Eye 5 times in head, one and a half times in interorbital width. Front straight; lower jaw projecting

beyond upper; mouth descending; end of maxillary just reaching line of orbit. Isthmus narrow. Teeth, 5.2–2.4. Scales, 15–58–7. Radii, D. I. 8; A. I. 11. Ventrals not reaching anal. Length, 6 inches.

Color above olive, with a blackish inferior border, extending from the superior margin of the orbit. Below this, a crimson band, and still lower, a blackish band, passing from the epiclavicular region above the lateral line to the basis of the caudal fin. Below this, crimson in front, silvery behind. Fins unspotted. Suborbital bones crimson; cheek golden.

Blackfoot Creek, Idaho. Collection No. 13.

CLINOSTOMUS MONTANUS, Cope, *sp. nov.*

Muzzle decurved, obtuse; jaws equal; end of maxillary extending beyond margin of orbit. Orbit large, entering the head 3.5 times and the interorbital region once. Length of head, one-fourth length to caudal fin; depth nearly equal. Scales, 11–12—56—6. Radii, D. I. 9; A. II–12. Length, 3.5 inches.

Olive above, a dark band extending from epiclavicular region above caudal line to caudal fin. Sides crimson as high as the lateral line.

Numerous specimens (No. 8) from Grass Creek, Idaho. This brightly colored species differs from the last in the obtuse muzzle, large eye, and smaller scales above the lateral line.

CATOSTOMUS GENEROSUS, G., (Proc. Acad. Nat. Sci. Phila., 1856, 174;)
Acomus generosus, G., (U. S. Pac. R. R. Surv., X, p. 221.)

This species is closely allied to the eastern *C. teres*, Mitch.: from Utah Lake.

PERCOMORPHI.

URANIDEA PUNCTULATA, Gill, (Proc. Boston Soc. N. H., 1862, p. 41.)

Gallatin Fork of the Missouri and Warm Springs, Utah.

COTTOPSIS SEMISCABER, Cope, *sp. nov.*

Radii, D. VII–18; A. 13; V. I–4; first ray of anal below third of second dorsal. Skin prickly above the lateral line, smooth below it posteriorly. Body compressed, profile rising rather steeply to the basis of first dorsal fin. Eye 4.5 times in head, .75 time in interorbital space. Muzzle contracted, maxillary bone reaching to below middle of pupil. Two spines on preoperculum. On an inferior anterior angle of operculum. Lateral line discontinued on last fourth of caudal peduncle. Head one-third length without caudal fin.

Below yellow; dorsal line with a series of dark spots; sides with large, dark clouds.

Three specimens from Fort Hall, Idaho.

CATALOGUE OF PLANTS.

BY PROF. THOMAS C. PORTER.

All the plants comprised in this catalogue were collected during the expedition of Dr. F. V. Hayden to the head-waters of the Yellowstone River in the summer of 1871, with the exception of a small number gathered by Dr. George Smith, in the month of August, on Gray's Peak and near Georgetown, Colorado Territory.

Prof. G. N. Allen acted as botanist, and Robert Adams, jr., as assistant, as far as Fort Ellis. After that time Mr. Adams took charge of the collections until his departure, about September 1.

Thanks are due to Doctors Torrey and Gray for valuable aid in difficult cases, and to Messrs. Engelmann, Olney, Thurber, Lesquereux, and Tuckerman for the determination of species in those orders to which they have devoted special attention.

RANUNCULACEÆ.

Clematis Douglasii, Hook.—Stinking Water Creek; Fort Ellis to the Yellowstone; Hot Sulphur Springs.

Clematis alpina, Mill., var. *Ochotensis*, Gray.—Gray's Peak, Colorado Territory, *Dr. Smith.*

Clematis ligusticifolia, Nutt.—Madison Valley; Fort Ellis to the Yellowstone.

Clematis verticillaris, D. C., (*C. Columbiana*, T. and G.)—Fort Ellis to the Yellowstone.

Anemone multifida, D. C.—Mountains south of Virginia City.

Thalictrum Fendleri, Engelm.—Mountains south of Virginia City; Fort Ellis to the Yellowstone.

Ranunculus aquatilis, L., var. *trichophyllus*, Chaix.—Salt Lake City, June 1.

Ranunculus aquatilis, L., var. *stagnalis*, D. C.—Stinking Water Creek; between Madison and Jefferson Rivers.

Ranunculus Flammula, L., var. *reptans*, Gray.—Mud Springs.

Ranunculus Cymbalaria, Pursh.—Weber River Valley and Salt Lake, Utah Territory, June; Stinking Water Creek, July 3.

Ranunculus multifidus, Pursh, var. *repens*, Hook.—Medicine Lodge.

Ranunculus nivalis, R. Br., var. *Eschscholtzii*, S. Watson.—Upper Falls of the Yellowstone.

Ranunculus repens, L.—Pleasant Valley; Upper Falls of the Yellowstone.

Caltha leptosepala, D. C.—Great Falls and Upper Falls of the Yellowstone.

Trollius laxus, Salisb.—Great Falls of the Yellowstone.

Aquilegia cœrulea, Torr.—Mountains south of Virginia City; Yellowstone Lake.

Aquilegia flavescens, S. Watson, (Clarence King's Rep., vol. V, p. 10.)—Fort Ellis to the Yellowstone; Hot Sulphur Springs; Lower Falls of the Yellowstone.

Delphinium elatum, L., var. (?) *occidentale*, S. Watson, (*loc. cit.*)—Stinking Water Creek; Madison Valley; Fort Ellis to the Yellowstone.

Delphinium Menziesii, D. C.—Mountains south of Virginia City; Stinking Water Creek.

Aconitum nasutum, Fisch.—Yellowstone Lake.

Actœa spicata, L., var. *arguta*, Torr.—Yellowstone Lake.

BERBERIDACEÆ.

Berberis Aquifolium, Pursh.—Salt Lake, June; Pleasant Valley.

NYMPHÆACEÆ.

Nuphar advena, Ait.—Madison Valley.

FUMARIACEÆ.

Corydalis aurea, Willd., var. *occidentalis*, Engelm.—Stinking Water Creek; Yellowstone Lake.

CRUCIFERÆ.

Nasturtium obtusum, Nutt.—Madison Valley.

Nasturtium palustre, D. C., var. *hispidum*, Gray.—Pleasant Valley.

Cardamine rhomboidea, D. C.—Gray's Peak, Colorado Territory, *Dr. Smith*.

Cardamine paucisecta, Benth.—Lower Falls of the Yellowstone.

Arabis hirsuta, Scop.—Stinking Water Creek.

Arabis perfoliata, Gray.—Weber River Valley, Utah Territory; mountains south of Virginia City.

Arabis Drummondii, Gray.—Yellowstone Lake; Upper Falls of the Yellowstone.

Arabis Drummondii, Gray, var. *alpina*, S. Watson.—Doane's Peak, near Yellowstone Lake, 10,000 feet altitude.

Arabis retrofracta, Graham.—Near Ogden, Utah Territory.

Erysimum cheiranthoides, L.—Stinking Water Creek.

Erysimum asperum, D. C.—Pleasant Valley; Stinking Water Creek; Fort Ellis to the Yellowstone.

Sisymbrium junceum, Bieb.—Mountains south of Virginia City.

Sisymbrium canescens, Nutt.—Pleasant Valley; Stinking Water Creek; Yellowstone Lake.

Smelowskia calycina, E. Meyer.—Mountains south of Virginia City.

Thelypodium integrifolium, Endl.—Stinking Water Creek; Fort Ellis to the Yellowstone; Hot Sulphur Springs.

Stanleya viridiflora, Nutt.—Stinking Water Creek.

Physaria didymocarpa, Gray.—Stinking Water Creek; Fort Ellis to the Yellowstone.

Vesicaria montana, Gray.—Near Cheyenne, Wyoming Territory, May 25.

Vesicaria Ludoviciana, D. C.—Near Cheyenne, Wyoming Territory, May 25.

Vesicaria alpina, Nutt.—Stinking Water Creek, July 3.

Draba aurea, Vahl.—Gray's Peak, Colorado Territory, *Dr. Smith*, August 10.

Draba alpina, L.—Mountains south of Virginia City.

Draba glacialis, Adams.—Doane's Peak, near Yellowstone Lake, 10,000 feet altitude.

Draba nemorosa, L.—Crow Agency.

Draba nemorosa, L., var. *lutea*, Gray.—Pleasant Valley; Yellowstone Lake; Upper Falls of the Yellowstone.

Lepidium intermedium, Gray.—Fish Creek, Jefferson Valley.

VIOLACEÆ.

Viola cucullata, Ait.—Pleasant Valley.

Viola canina, L.—Near Ogden, Utah Territory.

Viola Nuttallii, Pursh.—Cheyenne, Wyoming Territory, May 25.

CAPPARIDACEÆ.

Cleome integrifolia, T. and G.—Fort Ellis to the Yellowstone; Boteler's Ranch; Fish Creek, Jefferson Valley.

Cleome aurea, Nutt.—Near Ogden, Utah Territory, June 5.

CARYOPHYLLACEÆ.

Saponaria Vaccaria, Host.—Madison Valley. Most likely introduced.

Silene acaulis, L.—Mountains south of Virginia City; Yellowstone Lake.

Silene antirrhina, L.—Near Ogden, Utah Territory; Madison Valley.

Silene Menziesii, Hook.—Weber River Valley, Utah Territory; mountains south of Virginia City; Fort Ellis to the Yellowstone.

Lychnis Drummondii, S. Watson, (*Silene Drummondii*, Hook.)—Fort Ellis to the Yellowstone; Upper Falls of the Yellowstone.

Arenaria congesta, Nutt.—Pleasant Valley; Hot Sulphur Springs; Yellowstone Lake.

Arenaria Fendleri, Gray.—Stinking Water Creek.

Arenaria arctica, Stev.—Fort Ellis to the Yellowstone; high peaks near Yellowstone Lake.

Arenaria lateriflora, L.—Pleasant Valley.

Stellaria longipes, Goldie.—Pleasant Valley; Hot Sulphur Springs.

Stellaria crassifolia, Ehrh.—Mountains south of Virginia City.

Stellaria borealis, Bigelow.—Lower Falls of the Yellowstone.

Cerastium arvense, L.—Yellowstone Lake; Upper and Lower Falls of the Yellowstone.

Sagina Linnaei, Presl.—Fort Ellis to the Yellowstone; Mud Springs.

Paronychia sessiliflora, Nutt.—Fish Creek; Crow Agency.

PORTULACACEÆ.

Claytonia Caroliniana, Mx., Var. *lanceolata*, S. Watson, (*C. lanceolata*, Ph.)—Yellowstone Lake.

Claytonia perfoliata, Don.—Mountains near Ogden, Utah Territory.

Claytonia Chamissonis, Esch. and Ledeb.—Yellowstone Lake; Lower Falls of the Yellowstone.

Spraguea umbellata, Torr.—Mud Springs; Yellowstone Lake; Upper Falls of the Yellowstone.

Lewisia rediviva, Ph.—Yellowstone Lake.

MALVACEÆ.

Malvastrum coccineum, Gray.—Stinking Water Creek; Madison Valley; Fort Ellis to the Yellowstone; Fish Creek.

Malvastrum Munroanum, Gray.—Crow Agency; Madison Valley.

Sphæralcea acerifolia, Nutt.—Madison Valley; Fort Ellis to the Yellowstone.

LINACEÆ.

Linum perenne, L.—Pleasant Valley; Madison Valley; Hot Sulphur Springs; Upper Falls of the Yellowstone.

GERANIACEÆ.

Geranium Richardsonii, F. and M.—Fort Ellis to the Yellowstone; Yellowstone Lake.

Geranium Carolinianum, L.—Hot Sulphur Springs.

Geranium Fremontii, Torr., var. *Parryi*, Gray.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Geranium Fremontii, Torr., var. (?)—Madison Valley; Fort Ellis to the Yellowstone.—Differs from the variety *Parryi* in being far larger and more robust in every way. It is densely pilose throughout, with a portion of the hairs glandular.

Erodium cicutarium, L'Her.—Salt Lake, Utah Territory.

ANACARDIACEÆ.

Rhus Toxicodendron, L.—Near Ogden, Utah Territory.

Rhus glabra, L.—Near Ogden, Utah Territory.

Rhus aromatica, Ait., var. *trilobata*, Gray.—Weber River Valley, Utah Territory; Crow Agency.

RHAMNACEÆ.

Ceanothus velutinus, Dougl., var. *lævigatus*, T. and G.—Near Ogden, Utah Territory.

ACERACEÆ.

Acer glabrum, Torr.—Weber River Valley, Utah Territory; Crow Agency.

Acer grandidentatum, Nutt.—Weber River Valley, Utah Territory.

LEGUMINOSÆ.

Lupinus pusillus, Pursh.—Near Ogden, Utah Territory.

Lupinus sericeus, Pursh.—Near Ogden, Utah Territory.

Lupinus cæspitosus, Nutt.—Mud Springs; Yellowstone Lake.

Lupinus ornatus, Dougl.—Stinking Water Creek; Fort Ellis to the Yellowstone; Crow Agency.

Lupinus polyphyllus, Lindl.—Great Falls of the Yellowstone.

Lupinus leucophyllus, Lindl.—Madison Valley.

Lupinus laxiflorus, Dougl., var *tenellus*, T. and G.—Mud Springs; Yellowstone Lake.

Trifolium longipes, Nutt.—Mountains south of Virginia City; Stinking Water Creek.

Trifolium Haydeni, sp. nov.—Glabrous throughout, low, (2 to 3 inches,) cæspitose with a branching caudex, leafy at base; leaflets obovate, obtuse or tipped with a short, abrupt acumination, sharply denticulate, strongly veined; peduncles twice longer than the leaves; lower stipules scarious, obtuse, entire; upper ones lance-ovate and acute; heads few to many flowered; flowers purple, 6 to 8 lines long, in 2 to 3 verticils, persistent, reflexed in fruit; teeth of the calyx setaceous-subulate, about as long as the tube, and reaching half the length of the corolla; vexillum rounded at the apex, obtuse or emarginate.—It seems to approach *T. longipes*, Nutt., var. *pygmæum*, Gray, but is distinguished by its smoothness and broader obtuse vexillum.—Mountains south of Virginia City.

Psoralea lanceolata, Pursh.—Near Ogden, Utah Territory.

Glycyrrhiza lepidota, Nutt.—Fort Ellis to the Yellowstone.

Hedysarum Mackenzii, Rich.—Near Ogden, Utah Territory; Pleasant Valley.

Astragalus caryocarpus, Ker., in ft.—Fort Ellis to the Yellowstone.

Astragalus diphysus, Gray, in ft.—Stinking Water Creek.
Astragalus Canadensis, L., var. *Mortoni*, S. Watson.—Mountains south of Virginia City.
Astragalus hypoglottis, L.—Pleasant Valley; Stinking Water Creek.
Astragalus oroboides, Hornem., var. *Americanus*, Gray.—Mountains south of Virginia City.
Astragalus alpinus, L.—Mountains south of Virginia City; Yellowstone River.
Astragalus Missouriensis, Nutt.—Near Ogden, Utah Territory.
Astragalus Shortianus, Nutt.—Near Ogden, Utah Territory.
Astragalus Utahensis, T. and G., in fl. and ft.—Great Salt Lake.
Astragalus frigidus, Gray.—Fort Ellis to the Yellowstone.
Astragalus bisulcatus, Gray, in fl. and ft.—Madison Valley; Fort Ellis to the Yellowstone.
Astragalus pauciflorus, Hook.—Fort Ellis to the Yellowstone.
Astragalus campestris, Gray.—Fort Ellis to the Yellowstone.
Astragalus junceus, Gray.—Weber River Valley, Utah Territory.
Astragalus cæspitosus, Gray.—Near Cheyenne, Wyoming Territory, May 25.
Astragalus Kentrophyta, Gray.—Hot Sulphur Springs.
Oxytropis multiceps, Nutt.—Mountains south of Virginia City.
Oxytropis Lamberti, Pursh.—Cheyenne, Wyoming Territory; Salt Lake, Utah Territory.
Vicia Americana, Muhl.—Weber River Valley, Utah Territory.
Lathyrus polyphyllus, Nutt.—Near Ogden, Utah Territory.
Lathyrus ornatus, Nutt.—Cheyenne, Wyoming Territory, May 25.
Lathyrus palustris, L.—Stinking Water Creek; Madison Valley.
Lathyrus palustris, L., var. *myrtifolius*, Gray.—Utah Territory.
Thermopsis fabacea, D. C., var. *montana*, Gray.—Cheyenne, Wyoming Territory; Great Salt Lake; Pleasant Valley; Stinking Water Creek.

ROSACEÆ.

Prunus demissa, Walp.—Near Great Salt Lake, Utah Territory.
Spiræa opulifolia, L.—Weber River Valley, Utah Territory.
Spiræa betulæfolia, Pallas.—Fort Ellis to the Yellowstone; Hot Sulphur Springs; Lower Falls of the Yellowstone.
Spiræa cæspitosa, Nutt.—Between Madison and Jefferson Rivers.
Cercocarpus parvifolius, Nutt.—Mountains near Denver, Colorado Territory, *Dr. George Smith.*
Cercocarpus ledifolius, Nutt.—Near Ogden, Utah Territory; Stinking Water Creek.
Geum strictum, Ait.—Pleasant Valley; Gallatin River.
Geum triflorum, Pursh.—Pleasant Valley; Stinking Water Creek; Hot Sulphur Springs.
Geum Rossii, Seringe.—Gray's Peak, Colorado Territory, *Dr. George Smith.*
Sibbaldia procumbens, L.—Upper Falls of the Yellowstone.
Chamærhodos erecta, Bunge.—Madison Valley.
Ivesia Gordoni, T. and G.—Stinking Water Creek.
Potentilla Norvegica, L.—Weber River Valley, Utah Territory; Mud Springs; Upper Falls of the Yellowstone.
Potentilla millegrana, Engelm.—Mountains south of Virginia City.
Potentilla Pennsylvanica, L., var. *strigosa*, Pursh.—Stinking Water Creek.

Potentilla diversifolia, Lehm.—Pleasant Valley; Hot Sulphur Springs; Yellowstone Lake.

Potentilla pulcherrima, Lehm.—Fort Ellis to the Yellowstone; Hot Sulphur Springs.

Potentilla gracilis, Dougl., var. *flabelliformis*, Nutt.—Madison Valley; Fort Ellis to the Yellowstone.

Potentilla Nuttallii, Lehm.—Fort Ellis to the Yellowstone; Hot Sulphur Springs.

Potentilla Anserina, L.—Ogden, Utah Territory; Madison Valley; Yellowstone Lake; Crow agency.

Potentilla fruticosa, L.—Pleasant Valley; Hot Sulphur Springs.

Potentilla fissa, Nutt.—Gray's Peak, Colorado Territory, *Dr. George Smith;* Upper Falls of the Yellowstone.

Potentilla glandulosa, Lindl.—Mountains south of Virginia City; Lower Falls of the Yellowstone.

Rubus Nutkanus, Moç.—Fort Ellis to the Yellowstone; Hot Sulphur Springs.

Rubus strigosus, Michx.—Hot Sulphur Springs; Yellowstone Lake.

Cratægus rivularis, Nutt. (?)—Near Ogden, Utah Territory.

Cratægus tomentosa, L., var. *punctata*, Gray,—Weber River Valley, Utah Territory.

Amelanchier Canadensis, T. and G., var. *alnifolia*, T. and G.—Fort Ellis to the Yellowstone; Yellowstone Lake.

SAXIFRAGACEÆ.

Ribes hirtellum, Michx.—Yellowstone Lake.

Ribes oxycanthoides, L.—Stinking Water Creek.

Ribes prostratum, L'Her.—Yellowstone Lake.

Ribes lacustre, Poir.—Mountains south of Virginia City; Yellowstone Lake.

Ribes cereum, Dougl.—Yellowstone Lake; Crow Agency.

Ribes viscosissimum, Pursh.—Mountains south of Virginia City; Stinking Water Creek.

Ribes bracteosum, Dougl.—Falls of the Yellowstone.

Ribes aureum, Pursh.—Weber River Valley, Utah Territory.

Saxifraga oppositifolia, L.—Yellowstone Lake.

Saxifraga cæspitosa, L.—Mountains south of Virginia City.

Saxifraga serpyllifolia, Pursh.—Gray's Peak, Colorado Territory, *Dr. Smith.*

Saxifraga bronchialis, L.—Yellowstone Lake; Pleasant Valley.

Saxifraga punctata, L.—Hot Sulphur Springs; Yellowstone Lake; Falls of the Yellowstone.

Saxifraga nivalis, L.—Mountains south of Virginia City; Stinking Water Creek.

Saxifraga hieracifolia, Walds. and Kit.—Stinking Water Creek; Falls of the Yellowstone.

Saxifraga Jamesii, Dougl.—Hot Sulphur Springs.

Tellima parviflora, Hook.—Stinking Water Creek.

Mitella pentandra, Hook.—Yellowstone Lake.

Heuchera rubescens, Torr.—Near Great Salt Lake, June.

Heuchera cylindrica, Dougl.—Mountains south of Virginia City; Stinking Water Creek.

Heuchera parvifolia, Nutt.—Stinking Water Creek; Yellowstone Lake.

Parnassia palustris, L.—Upper Falls of the Yellowstone.

Parnassia parviflora, D. C.—Madison Valley.
Parnassia fimbriata, Banks.—Hot Sulphur Springs.

CRASSULACEÆ.

Sedum Rhodiola, D. C.—Gray's Peak, Colorado Territory, *Dr. Smith.*
Sedum rhodanthum, Gray.—Mud Springs; Yellowstone Lake; Upper Falls of the Yellowstone.
Sedum stenopetalum, Pursh.—Stinking Water Creek; Madison Valley; Hot Sulphur Springs.
Sedum debile, S. Watson,(Clarence King's Rep., v. V, p. 102.)—Mountains near Ogden, Utah Territory, June 5.
Sedum Douglasii, Hook.—Divide between the Snake River and Yellowstone Lake, 8,800 feet altitude.

ONAGRACEÆ.

Epilobium angustifolium, L.—Fort Ellis to the Yellowstone; Mud Springs; Yellowstone Lake.
Epilobium suffruticosum, Nutt.—Yellowstone Lake; Upper Falls of the Yellowstone.
Epilobium alpinum, L.—Lower Falls of the Yellowstone.
Epilobium tetragonum, L.—Fort Ellis to the Yellowstone; Mud Springs; Stinking Water Creek; Crow agency.—Variable, and in some of its forms closely approaching *E. coloratum*, Muhl.
Epilobium paniculatum, Nutt.—Fort Ellis to the Yellowstone.
Gayophytum diffusum, T. and G.—Yellowstone Lake.
Gayophytum ramosissimum, T. and G.—Great Salt Lake, June.
Gayophytum racemosum, T. and G.—Pleasant Valley; Mud Springs.
Œnothera biennis, L.—Fort Ellis to the Yellowstone; Hot Sulphur Springs; Madison Valley; Yellowstone Lake.
Œnothera coronopifolia, T. and G.—Near Ogden, Utah Territory.
Œnothera albicaulis, Nutt.—Fort Ellis to the Yellowstone; Mud Springs; Madison Valley.
Œnothera marginata, Nutt.—Cheyenne, Wyoming Territory, May 25.
Œnothera marginata, Nutt., var. *purpureæ*, S. Watson.—Stinking Water Creek; Hot Sulphur Springs.
Œnothera heterantha, Nutt.—Yellowstone Lake.
Gaura coccinea, Nutt.—Stinking Water Creek; Madison Valley; Jefferson Valley.
Gaura parviflora, Dougl.—Pleasant Valley.

LOASACEÆ.

Mentzelia albicaulis, Dougl.—Stinking Water Creek.
Mentzelia ornatus, T. and G.—Fort Ellis to the Yellowstone; Hot Sulphur Springs; Mud Springs.
Mentzelia lævicaulis, T. and G.— Hot Sulphur Springs.

CACTACEÆ.

Determined by Dr. George Engelmann.

Opuntia Missouriensis, Engelm.—Coalville, Utah Territory.
Opuntia sphærocarpa, Engelm. and Big., var (?) *Utahensis*, Engelm.—40 miles east of Fort Hall, Idaho Territory.

Mamillaria vivipara, Nutt.—40 miles east of Fort Hall, Idaho Territory; Yellowstone River.

Echinocactus Simpsoni, Engelm.—Great Salt Lake, Utah Territory.

UMBELLIFERÆ.

Bupleurum ranunculoides, L., var. (*B. angustum*, Hook. and Arn. Bot. Beechy.)—Mountains south of Virginia City.—Dr. Gray remarks, "It is the same as the plant from Kotzebue's Sound, and found in America only in that region before."

Carum Gairdneri, Benth. and Hook.—Hot Sulphur Springs; Yellowstone Lake; Lower Falls of the Yellowstone.

Sium angustifolium, L.—Fort Ellis to the Yellowstone.

Osmorrhiza nuda, Torr.—Yellowstone Lake.

Myrrahis occidentalis, Benth. and Hook.—Fort Ellis to the Yellowstone.

Cymopterus alpinus, Gray, var.—Stinking Water Creek; Upper Falls of the Yellowstone.

Cymopterus fœniculaceus, Nutt.—Mountains south of Virginia City.

Thaspium trifoliatum, Gray.—Mountains south of Virginia City.

Archangelica Gmelini, D. C. (?)—Gray's Peak, Colorado Territory. *Dr. Smith.*

Ferula multifida, Gray.—Utah Territory.

Heracleum lanatum, Michx.—Stinking Water Creek; Hot Sulphur Springs.

CORNACEÆ.

Cornus pubescens, Nutt.—Medicine Lodge, September 15.

CAPRIFOLIACEÆ.

Linnœa borealis, Gronov.—Hot Sulphur Springs; Upper and Lower Falls of the Yellowstone.

Symphoricarpus montanus, H. B. K.—Stinking Water Creek.

Symphoricarpus occidentalis, R. Br.—Yellowstone Lake; Madison Valley; Crow Agency.

Lonicera involucrata, Banks.—Pleasant Valley; Lower Falls of the Yellowstone.

Sambucus racemosa, L., var, *pubens*, S. Watson.—Lower Falls of the Yellowstone.

RUBIACEÆ.

Galium Aparine, L.—Madison Valley.

Galium multiflorum, Kellog.—Great Salt Lake, Utah Territory.

Galium trifidum, L.—Fort Ellis to the Yellowstone; Upper Falls of the Yellowstone; Pleasant Valley.

Galium triflorum, Michx.—Fort Ellis to the Yellowstone.

Galium boreale, L.—Madison Valley; Fort Ellis to the Yellowstone; Hot Sulphur Springs; Yellowstone Lake.

VALERIANACEÆ.

Valeriana edulis, Nutt.—Pleasant Valley; Stinking Water Creek.

Valeriana dioica, L., var *sylvatica*, S. Watson.—Pleasant Valley.

COMPOSITÆ.

Liatris punctata, Hook.—Fish Creek; Jefferson Valley; Boteler's Ranch.

Brickellia grandiflora, Nutt., var. *minor*, Gray.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Machæranthera canescens, Nutt.—Between Madison and Jefferson Rivers.

Aster integrifolius, Nutt.—Mud Springs; Yellowstone Lake; Falls of the Yellowstone.

Aster adscendens, Lindl., var.—Yellowstone Lake.

Aster falcatus, Lindl.—Hot Sulphur Springs.

Aster multiflorus, Ait.—Fish Creek, Jefferson Valley; Boteler's Ranch.

Aster glacialis, Nutt.—Lower Falls of the Yellowstone.

Aster salsuginosus, Rich.—Lower Falls of the Yellowstone.

Aster Haydeni, sp. nov.—Stems (1–3) from an erect transversely furrowed caudex, lanulose above, 3 to 5 inches high, each bearing a single head of medium size; radical leaves linear, grass-like, 3 to 4 inches long, 1 to 2 lines wide, rather acute, 3-nerved; cauline leaves few, smaller; scales of the involucre in about 3 series, lance-linear, often purplish, acute, with scarious lacerately fringed margins, shorter than the disk; rays apparently purplish; style of the disk-florets with subulate branches, of which the hispid portion is 3 times as long as the stigmatic; achenia linear-oblong, nearly 3 lines in length, 6 to 8 costate, slightly villous at the summit; setæ of the pappus minutely barbellate.—This plant belongs to the section *Xylorhiza* and is allied to *A. Andersonii*, Gray, from which it is chiefly distinguished by its almost glabrous achenium and narrower involucral scales.—Upper Falls of the Yellowstone.

Aster elegans, T. and G.—Hot Sulphur Springs.

Aster Engelmanni, Gray.—Yellowstone Lake.

Aster glaucus, T. and G.—Boteler's Ranch.

Erigeron Canadense, L.—Ogden, Utah Territory.

Erigeron compositum, Pursh.—Upper Falls of the Yellowstone.

Erigeron compositum, Pursh, var. *discoideum*, Gray.—Yellowstone Lake.

Erigeron grandiflorum, Hook., var. *elatius*, Gray.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Erigeron acre, L.—Madison Valley.

Erigeron Bellidiastrum, Nutt.—Near Ogden, Utah Territory.

Erigeron macranthum, Nutt.—Yellowstone Lake.

Erigeron glabellum, Nutt.—Pleasant Valley; Madison Valley.

Erigeron corymbosum, Nutt.—Pleasant Valley; Mud Springs.

Erigeron cæspitosum, Nutt.—Stinking Water Creek; Mud Springs.

Erigeron canescens, T. and G.—Stinking Water Creek.

Diplopappus alpinus, Nutt.—Stinking Water Creek.

Diplopappus alpinus, Nutt., var.—Mountains south of Virginia City.

Townsendia spathulata, Nutt.—Mountains south of Virginia City.

Townsendia grandiflora, Nutt.—Mountains south of Virginia City.

Townsendia scapigera, D. C. Eaton, (C. King's Rep., vol. V., p. 145,) var. *elatior*.—Scapes 3 to 9 inches high; leaves more or less acute.

Solidago Virga-aurea, L.—Mud Springs; Yellowstone Lake; Upper Falls of the Yellowstone.

Solidago Virga-aurea, L., var. *alpina*, T. and G.—Hot Sulphur Springs.

Solidago gigantea, Ait.—Boteler's Ranch; Yellowstone Lake.

Linosyris viscidiflora, T. and G.—Yellowstone River.

Linosyris Howardii, Parry.—Crow Agency.

Aplopappus acaulis, Gray.—Mountains south of Virginia City.

Aplopappus pygmæus, Gray.—Gray's Peak, Colorado Territory, *Dr. Smith.*

Aplopappus cæspitosus, Gray.—Stinking Water Creek.

Aplopappus Parryi, Gray.—Gray's Peak, Colorado Territory, *Dr. Smith.*

Aplopappus inuloides, T. and G.—Hot Sulphur Springs; Yellowstone Lake; Boteler's Ranch.

Chrysopsis villosa, Nutt.—Stinking Water Creek; Fort Ellis to the Yellowstone; Hot Springs; Madison Valley.—Several forms.

Grindelia squarrosa, Don.—Madison Valley; Fish Creek.

Wyethia amplexicaulis, Nutt.—Near Ogden, Utah Territory.

Balsamorrhiza Hookeri, Nutt.—Pleasant Valley.

Balamorrhiza macrophylla, Nutt.—Near Ogden, Utah Territory.

Rudbeckia laciniata, L.—Madison Valley.

Helianthus lenticularis, Dougl.—Madison Valley.

Helianthus petiolaris, Nutt.—Madison Valley.

Heliomeris multiflora, Nutt.—Yellowstone Lake.

Helianthella uniflora, T. and G.—Fort Ellis to the Yellowstone; Yellowstone Lake.

Gaillardia aristata, Pursh.—Stinking Water Creek; Fort Ellis to the Yellowstone; Madison Valley.

Chænactis Douglasii, Hook. and Arn.—Stinking Water Creek; Hot Sulphur Springs; Madison Valley.

Hymenopappus tenuifolius, Pursh.—Stinking Water Creek.

Bahia oppositifolia, Nutt.—Golden City, Colorado Territory, *Dr. Smith.*

Bahia leucophylla, D. C.—Hot Sulphur Springs; Mud Springs; Yellowstone Lake; Falls of the Yellowstone.

Actinella acaulis, Nutt.—Cheyenne, Wyoming Territory, May 25.

Actinella grandiflora, T. and G.—Stinking Water Creek; Pleasant Valley.

Helenium autumnale, L.—Fish Creek, Jefferson Valley.

Layia heterotricha, Hook. and Arn.—Great Salt Lake, June 1–5.

Amida hirsuta, Nutt.—Fort Ellis to the Yellowstone; Great Falls of the Yellowstone.

Achillea Millefolium, L.—Stinking Water Creek; Fort Ellis to the Yellowstone; Mud Springs.

Matricaria discoidea, D. C.—Great Salt Lake, June 1–5.

Artemisia dracunculoides, Pursh.—Fish Creek; Crow Agency; Fort Ellis to the Yellowstone; Yellowstone Lake.

Artemisia trifida, Nutt.—Spring Creek, September 20.

Artemisia tridentata, Nutt.—Yellowstone River; Mud Springs.

Artemisia Ludoviciana, Nutt., var. *latifolia*, T. and G.—Yellowstone Lake; Crow Agency.

Artemisia vulgaris, L.—Madison Valley; Mud Springs.

Artemisia biennis, Willd.—Fish Creek; Medicine Lodge.

Artemisia frigida, Willd.—Fort Ellis to the Yellowstone; Crow Agency; Fish Creek.

Artemisia Richardsoniana, Bess.—Lower Falls of the Yellowstone.

Gnaphalium luteo-album, L., var. *Sprengelii*, D. C. Eaton.—Mud Springs.

Antennaria margaritacea, R. Br.—Fort Ellis to the Yellowstone; Yellowstone Lake.

Antennaria Carpathica, R. Br., var. *pulcherrima*, Hook.—Mountains south of Virginia City.

Antennaria alpina, Gærtn.—Mud Springs; Falls of the Yellowstone.

Antennaria dioica, Gærtn.—Fort Ellis to the Yellowstone; Yellowstone Lake.

Antennaria racemosa, Hook.—Fort Ellis to the Yellowstone; Madison Valley.

Senecio lugens, Rich., var. *Hookeri*, D. C. Eaton, (Clarence King's Rep., vol. V, p. 188.)—Near Great Salt Lake; Upper Falls of the Yellowstone.

Senecio lugens, Rich., var. *exaltatus*, D. C. Eaton, (*loc. cit.*)—Gray's Peak, Colorado Territory, *Dr. George Smith*; mountains south of Virginia City.

Senecio hydrophilus, Nutt.—Mud Springs; Stevenson's Island, Yellowstone Lake, July 28.

Senecio triangularis, Hook.—Madison Valley; Yellowstone Lake; Upper Falls of the Yellowstone.

Senecio Andinus, Nutt.—Madison Valley; Crow Agency.

Senicio aureus, L., var. *obovatus*, T. and G.—Weber River Valley, Utah Territory; Pleasant Valley.

Senecio aureus, L., var. *borealis*, T. and G.—Cheyenne, Wyoming Territory; Gray's Peak, Colorado Territory, *Dr. George Smith.*

Senecio aureus, L., var. *croceus*, Gray.—Near Ogden, Utah Territory.

Senecio canus, Hook.—Hot Sulphur Springs.

Senecio cernuus, Gray.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Senecio eremophilus, Rich.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Senecio Fremontii, T. and G.—Boteler's Ranch.

Senecio amplectens, Gray.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Arnica angustifolia, Vahl.—Mountains south of Virginia City; Yellowstone Lake.

Arnica Chamissonis, Less.—Hot Sulphur Springs; Yellowstone Lake; Falls of the Yellowstone.

Arnica mollis, Hook.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Arnica cordifolia, Hook.—Yellowstone Lake.

Tetradymia canescens, D. C., var. *inermis*, Gray.—Stinking Water Creek; Fort Ellis to the Yellowstone.

Cirsium discolor, Spreng.—Madison Valley.

Cirsium undulatum, Gray.—Fort Ellis to the Yellowstone.

Cirsium foliosum, D. C.—Hot Sulphur Springs.

Cirsium Drummondii, T. and G.—Pleasant Valley; Yellowstone Lake.

Echinais carlinoides, Cass., var. *nutans*, D. C.—Madison Valley.

Calais nutans, Gray.—Mountains south of Virginia City.

Stephanomeria exigua, Nutt.—Mud Springs.

Hieracium Scouleri, Hook.—Yellowstone Lake.

Hieracium albiflorum, Hook.—Yellowstone Lake.

Crepis runcinata, T. and G.—Yellowstone Lake.

Crepis occidentalis, Nutt.—Lower Falls of the Yellowstone.

Crepis acuminata, Nutt.—Mountains south of Virginia City.

Lygodesmia juncea, Don.—Fort Ellis to Yellowstone; Mud Springs; Madison Valley.

Lygodesmia spinosa, Nutt.—Mountains south of Virginia City.

Macrorhynchus glaucus, D. C. Eaton, (*Troximon glaucus*, Nutt,) var. *dasycephalus*, T. and G.—Stinking Water Creek; Fort Ellis to the Yellowstone.

Macrorhynchus troximoides, T. and G.—Fort Ellis to the Yellowstone; Yellowstone Lake; Upper Falls of the Yellowstone.

Taraxacum Dens-leonis, Desf.—Fort Ellis to the Yellowstone.

Mulgedium pulchellum, Nutt.—Fort Ellis to the Yellowstone; Fish Creek; Madison Valley.

LOBELIACEÆ.

PORTERELLA, *gen. nov.*, (by Dr. John Torrey.)

Calyx 5-cleft; the tube obconical and adherent. Tube of the corolla entire, cylindrical, straight; limb bi-labiate; the upper lip erect, 2-parted; lower lip of 3 nearly obovate-cuneate, erect lobes. Filaments united their whole length; anthers included, smooth, the two lower ones with a minute bristle at the tip. Capsule oval-obconical, 2-celled; placentæ many-seeded. Seeds elongated, tapering at each end.—A small branching annual, with entire linear-lanceolate leaves, and blue, axillary, pedicellate flowers.

Porterella carnulosa, (*Lobelia carnulosa*, Hook. and Arn.)—Plant glabrous, 2–3 inches high, branching from the base; leaves ½ an inch long, sessile, acute; pedicels shorter than the leaves; tube of the calyx acute at the base, lobes linear-lanceolate, erect; corolla nearly twice as long as the lobes of the calyx.—Muddy shores of Yellowstone Lake, along with *Limosella aquatica*, L.; Madison Valley. It has also been found in the Snake country of Oregon. The genus is dedicated to Professor Thomas C. Porter, and the diminutive form used because suited to the plant, and also because *Porteria* is already preoccupied by a South American genus.

CAMPANULACEÆ.

Campanula rotundifolia, L.—Stinking Water Creek; Fort Ellis to the Yellowstone; Hot Sulphur Springs.

Campanula rotundifolia, L., var. *linifolia*, Gray.—Mud Springs.

Specularia perfoliata, A. D. C.—Ogden, Utah Territory.

ERICACEÆ.

Vaccinium Myrtillus, L.—Fort Ellis to the Yellowstone; Upper Falls of the Yellowstone.

Arctostaphylos Uva-ursi, Spreng.—Fort Ellis to the Yellowstone.

Bryanthus empetriformis, Gray, (Proc. Am. Acad., vol. VII. p. 367.)—Upper Falls of the Yellowstone.

Ledum glandulosum, Nutt.—Madison Valley.

Pyrola rotundifolia, L., var. *incarnata*, Hook.—Upper Falls of the Yellowstone.

Pyrola chlorantha, Swtz.—Yellowstone Lake; Hot Sulphur Springs.

Pyrola secunda, L.—Pleasant Valley; Yellowstone Lake.

Moneses uniflora, Gray.—Yellowstone Lake; Falls of the Yellowstone.

Chimaphila umbellata, Nutt.—Yellowstone Lake.

Pterospora Andromedea, Nutt.—Madison Valley; Upper Falls of the Yellowstone.

PLANTAGINACEÆ.

Plantago eriopoda, Torr.—Mountains south of Virginia City.

PRIMULACEÆ.

Primula farinosa, L.—Mountains south of Virginia City; Stinking Water Creek.

Primula Parryi, Gray.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Dodecatheon Meadia, L.—Pleasant Valley; Stinking Water Creek.

Androsace septentrionalis, L.—Yellowstone Lake; Upper Falls of the Yellowstone.

Androsace filiformis, Retz.—Fort Ellis to the Yellowstone; Mud Springs.

Lysimachia ciliata, L.—Fort Ellis to the Yellowstone.

OROBANCHACEÆ.

Aphyllon fasciculatum, T. and G.—Madison Valley; Yellowstone Lake.

Phelipæa Ludoviciana, Don.—Yellowstone Lake.—The anthers are wholly glabrous.

SCROPHULARIACEÆ.

Scrophularia nodosa, L.—Ogden, Utah Territory.

Collinsia parviflora, Dougl.—Stinking Water Creek; Fort Ellis to the Yellowstone.

Pentstemon Menziesii, Hook., var. *Scouleri*, Gray, (Proc. Am. Acad., vol. VI, p. 59.)—Divide between Yellowstone Lake and Snake River.

Pentstemon Menziesii, Hook., var. *Lewisii*, Gray, (*loc. cit.*)—Yellowstone Lake.

Pentstemon glaber, Pursh.—Utah Territory.

Pentstemon cyananthus, Hook.—Pleasant Valley.

Pentstemon cristatus, Nutt.—Stinking Water Creek.

Pentstemon acuminatus, Dougl.—Georgetown, Colorado Territory, *Dr. George Smith.*

Pentstemon cæruleus, Nutt.—Cheyenne, Wyoming Territory, May.

Pentstemon confertus, Dougl., var. *cæruleo-purpureus*, Gray.—Pleasant Valley; Stinking Water Creek; Yellowstone Lake.

Pentstemon attenuatus, Lindl.—Stinking Water Creek.

Pentstemon deustus, Dougl.—Madison Valley.

Mimulus luteus, L.—Great Salt Lake; Pleasant Valley; Mud Springs; Yellowstone Lake; Lower Falls of the Yellowstone.

Mimulus Lewisii, Pursh.—Lower Falls of the Yellowstone.

Limosella aquatica, L.—Muddy shores of Yellowstone Lake.

Veronica Americana, Schwein.—Stinking Water Creek; Crow agency.

Veronica alpina, L.—Yellowstone Lake; Falls of the Yellowstone.

Veronica serpyllifolia, L.—Mud Spring; Falls of the Yellowstone.

Veronica scutellata, L.—Upper Falls of the Yellowstone.

Veronica peregrina, L., var. (?)—Pleasant Valley.—Probably a dwarf form; two inches in height.

Synthyris alpina, Gray, (Enum. Pl. Parry, p. 25.)—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Synthyris pinnatifida, S. Watson, (Clarence King's Rep., v. V, p. 227, pl. 22,) var. (?)—Mountains south of Virginia City.—The radical leaves of our plant are much more dissected than is represented in Watson's figure, the cauline leaves or bracts more numerous, and the racemes longer and more densely flowered.

Castilleia affinis, Hook. and Arn., var. *minor*, Gray, (Am. Jour. Sci., n. s., vol. 34, p. 336.)—Mud Springs.

Castilleia pallida, Kunth.—Stinking Water Creek; Fort Ellis to the Yellowstone; Madison Valley; Hot Springs; Yellowstone Lake.

Castilleia parviflora, Bong.—Utah Territory; Pleasant Valley.

Pedicularis Grœnlandica, Retz.—Madison Valley; Yellowstone Lake; Great Falls of the Yellowstone.

Pedicularis bracteosa, Benth.—Yellowstone Lake; Fort Ellis to the Yellowstone.

Pedicularis contorta, Benth., (fide Gray.)—Mountains south of Virginia City.—Reported before by Hooker only, from Mount Rainier, north of the Columbia.

Orthocarpus luteus, Nutt.—Utah Territory; Yellowstone Lake.

VERBENACEÆ.

Verbena hastata, L.—Fish Creek, Jefferson Valley.

Verbena bracteosa, Michx.—Between Madison and Jefferson Rivers.

LABIATÆ.

Mentha Canadensis, L.—Madison Valley; Crow Agency.

Mentha Canadensis, L., var. *glabrata*, Benth.—Madison Valley.

Monarda fistulosa, L.—Fort Ellis to the Yellowstone; Madison Valley.

Lophanthus urticæfolius, Benth.—Fort Ellis to the Yellowstone.

Dracocephalum parviflorum, D. C.—Hot Sulphur Springs.

Brunella vulgaris, L.—Mud Springs.

Scutellaria resinosa, Torr.—Near Ogden, Utah Territory.

Scutellaria galericulata, L.—Utah Territory.

Stachys palustris, L.—Stinking Water Creek; Madison Valley.

BORRAGINACEÆ.

Mertensia Sibirica, Don.—Yellowstone Lake; Lower Falls of the Yellowstone.

Mertensia alpina, Don.—Utah Territory; Pleasant Valley; Yellowstone Lake.

Lithospermum longiflorum, Spreng.—Utah Territory.

Eritrichium villosum, D. C., var. *aretioides*, Hook.—Mountains south of Virginia City; high peaks around Yellowstone Lake.

Eritrichium Californicum, D. C.—Utah Territory; Pleasant Valley.

Eritrichium glomeratum, D. C.—Upper Falls of the Yellowstone; Cheyenne, Wyoming Territory.

Eritrichium angustifolium, Torr.—Ogden, Utah Territory.

Eritrichium crassisepalum, T. and G.—Pleasant Valley, Northern Idaho.

Eritrichium leiocarpum, S. Watson, (*Krynitzkia*, F. and M.)—Stinking Water Creek; Mud Springs.

Echinospermum deflexum, Lehm., var. *floribundum*, S. Watson (*E. floribundum*, Lehm.)—Pleasant Valley; Stinking Water Creek; Madison Valley.

Echinospermum Redowski, Lehm. var. *occidentale*, S. Watson.—Cheyenne, Wyoming Territory; Great Salt Lake; Stinking Water Creek; Yellowstone Lake.

Myosotis sylvatica, Hoffm., var. *alpestris*, Koch.—Mountains south of Virginia City; Yellowstone Lake.

HYDROPHYLLACEÆ.

Hydrophyllum capitatum, Dougl.—Fort Ellis to the Yellowstone.

Phacelia circinata, Jacq.—Stinking Water Creek; Hot Sulphur Springs; Madison Valley; Yellowstone Lake.

Phacelia Menziesii, Torr.—Stinking Water Creek; Fort Ellis to the Yellowstone; Mud Springs.

Phacelia sericea, Gray.—Mountains south of Virginia City.

Phacelia Franklinii, Gray.—Yellowstone Lake.

POLEMONIACEÆ.

Phlox cæspitosa, Nutt., var. *condensata*, Gray, (Proc. Am. Acad., vol. VIII, p. 254.)—Near Cheyenne, Wyoming Territory, May.

Phlox Douglasii, Hook., var. *longifolia*, Gray, (*loc. cit.*)—Utah Territory.

Phlox Douglasii, Hook., var. *diffusa*, Gray, (*loc. cit.*)—Lower Falls of the Yellowstone.

Phlox longifolia, Nutt.—Pleasant Valley; Stinking Water Creek.

Phlox longifolia, Nutt., var. *brevifolia*, Gray, (*loc. cit.*, p. 255.)—High rocks on Yellowstone Lake.

Collomia grandiflora, Dougl.—Weber River Valley, Utah Territory.

Collomia linearis, Nutt.—Fort Ellis to the Yellowstone; Mud Springs; Yellowstone Lake; Lower Falls of the Yellowstone.

Collomia gracilis, Dougl.—Vicinity of Ogden, Utah Territory.

Gilia liniflora, Benth., var. *pharnaceoides*, Gray, (Proc. Am. Acad., vol. VIII, p. 263.)—Fort Ellis to the Yellowstone; Mud Springs.

Gilia pungens, Benth., var. *Hookeri*, Gray, (*loc. cit.*, p. 268.)—Stinking Water Creek.

Gilia spicata, Nutt.—Cheyenne, Wyoming Territory.

Gilia congesta, Hook.—Pleasant Valley.

Gilia congesta, Hook, var. *crebrifolia*, Gray, (*loc. cit.*, p. 274.)—Stinking Water Creek.

Gilia aggregata, Spreng.—Utah Territory. The variety with white flowers from Georgetown, Colorado Territory, *Dr. George Smith.*

Gilia inconspicua, Dougl.—Weber River Valley, Utah Territory.

Polemonium confertum, Gray.—Yellowstone Lake; Upper Falls of the Yellowstone.

Polemonium cæruleum, L.—Yellowstone Lake.

Polemonium cæruleum, L., var. *foliosissimum*, Gray, (*loc. cit.*, p. 281.)—Stevenson's Island, Yellowstone Lake.

SOLANACEÆ.

Solanum triflorum, Nutt.—Fort Ellis to the Yellowstone; between Madison and Jefferson Rivers.

Nicotiana attenuata, Torr., (Watson in Clarence King's Rep. vol. V, p. 276, pl. 27.)—Gray's Peak, Colorado Territory, *Dr. George Smith.*

GENTIANACEÆ.

Frasera speciosa, Dougl.—Mountains south of Virginia City; Yellowstone Lake.

Halenia deflexa, Griseb.—Madison River.

Gentiana detonsa, Fries.—Mud Springs; Yellowstone Lake; Falls of the Yellowstone River.

Gentiana Amarella, L., var. *stricta*, S. Watson, (Clarence King's Rep., vol. V, p. 277.)—Yellowstone Lake; Upper Falls of the Yellowstone.

Gentiana frigida, Haenke, var. *algida*, Griseb.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Gentiana affinis, Smith.—Mud Springs; Yellowstone Lake; Upper Falls of the Yellowstone.

Gentiana Parryi, Engelm.—Gray's Peak, Colorado Territory, *Dr. Smith.*

APOCYNACEÆ.

Apocynum cannabinum, L.—Mud Springs.
Apocynum androsæmifolium, L.—Fort Ellis to the Yellowstone.
Acerates decumbens, Decaisne.—Madison Valley.

NYCTAGINACEÆ.

Oxybaphus angustifolius, Sweet.—Madison Valley; Crow Agency.
Abronia fragrans, Nutt.—Great Salt Lake.
Abronia fragrans, Nutt., var.—Yellowstone Lake.—Varies from the type in its smaller involucral bracts, which do not exceed three lines in length, and its more delicate and branching habit.

CHENOPODIACEÆ.

Chenopodium album, L.—Mud Springs; Yellowstone Lake.
Chenopodium hybridum, L.—Fort Ellis to the Yellowstone; Mud Springs.
Blitum capitatum, L.—Pleasant Valley; Yellowstone Lake.
Blitum polymorphum, E. Meyer.—Fish Creek, Jefferson Valley.
Monolepis chenopodioides, Moq.—Pleasant Valley; Crow Agency.
Obione canescens, Moq.—Madison Valley, Medicine Lodge.
Suæda depressa, Ledeb.—Crow Agency.

AMARANTACEÆ.

Amarantus albus, L.—Fish Creek; Jefferson Valley.

POLYGONACEÆ.

Eriogonum cæspitosum, Nutt.—Pleasant Valley; Northern Idaho.
Eriogonum heracleoides, Nutt.—Utah Territory; Fort Ellis to the Yellowstone.
Eriogonum umbellatum, Torr.—Utah Territory; Pleasant Valley; Stinking Water Creek; Yellowstone Lake.
Eriogonum ovalifolium, Nutt.—Stinking Water Creek; Yellowstone Lake.
Eriogonum microthecum, Nutt.—Between Madison and Jefferson River; Gallatin River.
Oxyria digyna, Campd.—Pleasant Valley; Yellowstone Lake; Upper Falls of the Yellowstone.
Rumex salicifolius, Weinm.—Stinking Water Creek; Yellowstone Lake.
Rumex paucifolius, Nutt.—Pleasant Valley; Northern Idaho.
Polygonum viviparum, L.—Falls of the Yellowstone.
Polygonum Bistorta, L., var. *oblongifolium*, Meisn.—Pleasant Valley; Hot Sulphur Springs; Falls of the Yellowstone.
Polygonum amphibium, L.—Yellowstone Lake; Medicine Lodge.
Polygonum lapathifolium, Ait., var. *incanum*, Koch.—Madison River.
Polygonum tenue, Michx.—Fort Ellis to the Yellowstone; Mud Springs; Yellowstone Lake.
Polygonum tenue, Michx., var. *latifolium*, Engelm.—Mud Springs.

Polygonum coarctatum, Dougl., var. *minus*, Meisn.—Yellowstone Lake.
Polygonum Convolvulus, L.—Fort Ellis to the Yellowstone.

ELÆAGNACEÆ.

Shepherdia Canadensis, Nutt.—Fort Ellis to the Yellowstone; Yellowstone Lake.

SANTALACEÆ.

Comandra pallida, D. C.—Utah Territory; Pleasant Valley.

LORANTHACEÆ.

Arceuthobium Americanum, Nutt., in Herb. Durand.—Yellowstone Lake.—A specimen was sent to Dr. Engelmann, who kindly furnished the name and the following note: "You follow Hooker in naming it *A. Oxycedri*, which, however, has never been found in America. Your plant is the same as the male figured by Hooker (Fl. Bor. Am., 2, t. 99) and no doubt from the same tree, *Pinus contorta*, and is a female. Hooker's female is a distinct species. Mr. Meehan obtained the same plant in Colorado from the same tree last summer. Nuttall also found only the male, as well as Drummond and several other collectors."

CALLITRICHACEÆ.

Callitriche verna, L.—Lower Falls of the Yellowstone.

EUPHORBIACEÆ.

Euphorbia glyptosperma, Engelm.—Stinking Water Creek; Yellowstone Lake.
Euphorbia dictyosperma, F. and M.—Madison Valley.
Euphorbia montana, Engelm.—Crow agency.

URTICACEÆ.

Urtica gracilis, Ait.—Stinking Water Creek; Medicine Lodge.

CUPULIFERÆ.

Quercus alba, L., var. *Gunnisoni*, Torr.—Mountains near Ogden, Utah Territory.

BETULACEÆ.

Betula occidentalis, Hook.—Yellowstone River; Spring Creek, Northern Idaho.
Betula glandulosa, Michx.—Pleasant Valley; Yellowstone Lake.
Alnus viridis, D. C.—Yellowstone Lake.
Alnus incana, Willd.—Madison Valley.

SALICACEÆ.

Salix longifolia, Muhl.—Utah Territory; Crow agency.—In some specimens, the serratures of the leaves are very sparse or almost obsolete.
Salix longifolia, Muhl., var. *argyrophylla*, Nutt.—Utah Territory.
Salix nigra, Marsh., var. *amygdaloides*, Anders.—Utah Territory.
Salix cordata, Muhl., var.—Weber River Valley, Utah Territory.

Salix cordata, Muhl., var.—Stinking Water Creek.

Salix arctica, Pallas, var.—Upper Falls of the Yellowstone.

Populus balsamifera, L., var. *angustifolia*, S. Watson, (*P. angustifolia*, James.)—Stinking Water Creek; Medicine Lodge.

Populus tremuloides, Michx.—Yellowstone Lake.

CONIFERÆ.

Pinus monophylla, Torr. (?)—Near the summit of Emigrant Peak, Yellowstone River.

Pinus contorta, Dougl.—Yellowstone Lake; Yellowstone River.

Pinus flexilis, James.—Doane's Peak, near Yellowstone Lake; divide between Yellowstone Lake and Snake River.

Abies Engelmanni, Parry.—Yellowstone Lake.

Abies Menziesii, Lindl.—Yellowstone Lake.

Abies Donglasii, Lindl.—Yellowstone Lake; Yellowstone River.

Juniperus communis, L. Yellowstone Lake.

Juniperus occidentalis, Hook.—Mud Springs.

LEMNACEÆ.

Lemna minor, L.—Between Madison and Jefferson Rivers.

Lemna trisulca, L.—Yellowstone Lake.

TYPHACEÆ.

Sparganium simplex, Huds., var. *androcladum*, Gray.—Medicine Lodge.

Sparganium simplex, Huds., var. *angustifolium*, Gray.—Yellowstone Lake.

NAIADACEÆ.

Potamogeton rufescens, Schrad.—Hot Sulphur Springs.

Potamogeton perfoliatus, L., var. *lanceolatus*, Robbins.—Madison River.

Potamogeton pectinatus, L., Form.—Gallatin River.

ALISMACEÆ.

Triglochin maritimum, L.—Stinking Water Creek.

ORCHIDACEÆ.

Habenaria hyperborea, R. Br.—Mountains south of Virginia City.

Habenaria dilatata, Gray.—Fort Ellis to the Yellowstone; Yellowstone Lake.

Spiranthes Romanzoffiana, Cham.—Mud Springs; Upper Falls of the Yellowstone.

IRIDACEÆ.

Iris tenax, Dougl.—Cheyenne, Wyoming Territory; Stinking Water Creek; Fort Ellis to the Yellowstone.

Sisyrinchium Bermudiana, L.—Stinking Water Creek; Upper Falls of the Yellowstone.

LILIACEÆ.

Zygadenus glaucus, Nutt.—Stinking Water Creek; Hot Sulphur Springs; Madison Valley.

Zygadenus Nuttallii, Gray.—Mountains south of Virginia City; Stinking Water Creek.

Xerophyllum tenax, Pursh.—Fort Ellis to the Yellowstone.

Veratrum album, L.—Utah Territory.

Prosartes trachycarpa, S. Watson, (Clarence King's Rep., vol. V, p. 344.)—Mountains near Ogden, Utah Territory.

Streptopus amplexifolius, D. C.—Upper Falls of the Yellowstone.

Smilacina racemosa, Desf., var. *amplexicaulis*, S. Watson, (*S. amplexicaulis*, Nutt.)—Pleasant Valley; Stinking Water Creek.

Smilacina stellata, Desf.—Pleasant Valley; Yellowstone Lake.

Fritillaria atropurpurea, Nutt., in ft.—Yellowstone Lake.

Calochortus Nuttallii, T. and G.—Yellowstone Lake.

Calochortus eurycarpus, S. Watson, (Clarence King's Rep., vol. V, p. 348.)—Yellowstone Lake.

Lloydia serotina, Reich.—Pleasant Valley.

Erythronium grandiflorum, Pursh.—Madison Valley.

Leucocrinum montanum, Nutt.—Cheyenne, Wyoming Territory.

Camassia esculenta, Lindl.—Utah Territory; Pleasant Valley.

Milla grandiflora, Baker, (*Triteleia grandiflora*, Lindl.)—Utah Territory; Fort Ellis to the Yellowstone.

Allium brevistylum, S. Watson, (Clarence King's Rep., vol. V, p. 350.)—Yellowstone Lake.

Allium bisceptrum, S. Watson, (*loc. cit.*, p. 351, pl. xxxvii.)—Fort Ellis to the Yellowstone.

Allium cernuum, Roth.—Pleasant Valley, Northern Idaho.

Allium stellatum, Fraser.—Mud Springs.

Allium acuminatum, Hook.—Ogden, Utah Territory.

Allium Schœnoprasum, L.—Mountains south of Virginia City.

JUNCACEÆ.

Luzula spadicea, D. C., var. *parviflora*, Ledeb.—Yellowstone Lake; Falls of the Yellowstone.

Luzula campestris, D. C., var. *nivalis*, Wahl.—Gray's Peak, Colorado Territory, Dr. George Smith.

Luzula spicata, Desv.—Upper Falls of the Yellowstone.

Juncus Balticus, Deth., var. *montanus*, Engelm.—Mountains south of Virginia City.

Juncus Drummondii, E. Meyer.—Yellowstone Lake; Lower Falls of the Yellowstone.

Juncus Parryi, Engelm.—Upper Falls of the Yellowstone.

Juncus tenuis, Willd., var. *congestus*, Engelm.—Mud Springs.

Juncus bufonius, L.—Fish Creek, Jefferson Valley; Crow Agency.

Juncus longistylis, Torr.—Pleasant Valley; Madison Valley.

Juncus nodosus, L., var. *megacephalus*, Torr.—Fish Creek; Crow Agency.

Juncus Canadensis, J. Gay, var. *coarctatus*, Engelm.—Mud Springs.

Juncus Mertensianus, Bong.—Yellowstone Lake; Great Falls of the Yellowstone; Madison Valley.

Juntus Mertensianus, Bong., var. *paniculatus*, Engelm.—Pleasant Valley.

Juncus xiphioides, E. Meyer, var. *montanus*, Engelm.—Mud Springs; Yellowstone Lake.

CYPERACEÆ.

Determined by S. T. Olney, esq.

Eleocharis olivacea, Torr.—Mud Springs.

Eleocharis palustris, R. B.—Lower Falls of the Yellowstone.

Eleocharis acicularis, R. Br.—Crow Agency.

Scirpus validus, Vahl.—Crow Agency.

Scirpus atrovirens, Muhl.—Fort Ellis to the Yellowstone.

Carex Hallii, Olney, ined.—"It is the same as Hall and Harbour's 617, named by Booth *C. Parryana*, but quite unlike all the arctic specimens I have seen of that species. To the eye it resembles *C. scirpoidea*, when the latter has a second small spike, but differs in having a shorter, more obovate, smooth, many-nerved perigynium, and more entire scales, not ciliated. I propose that it should bear the name of Mr. Elihu Hall, of Athens, Illinois, its first collector."—Pleasant Valley.

Carex vallicola, Dew.—Pleasant Valley.—"All I have seen of this has been of Hayden's collection."—Olney.

Carex siccata, Dew.—Pleasant Valley; Mud Springs.

Carex Douglassii, Boott.—Mountains south of Virginia City.

Carex Bonplandii, Kunth, (?) var. *minor*, Boott.—Falls of the Yellowstone.

Carex festiva, Dew.—Fort Ellis to the Yellowstone; Mud Springs; Yellowstone Lake.

Carex aquatilis, Wahl.—Pleasant Valley; Upper Falls of the Yellowstone.

Carex aquatilis, Wahl., var. *minor*, Boott.—Yellowstone Lake; Upper Falls of the Yellowstone.—The perigynia have denticulated margins, a character which may carry this plant elsewhere.

Carex rigida, Good.—Hot Sulphur Springs; Falls of the Yellowstone.

Carex aurea, Nutt.—Fort Ellis to the Yellowstone.

Carex Raynoldsii, Dew.—Yellowstone Lake; Great Falls of the Yellowstone.

Carex lanuginosa, Michx.—Stinking Water Creek.

Carex æmathorhyncha, Desv.—Pleasant Valley, Northern Idaho.

Carex utriculata, Boott., var. *minor*, Boott.—Yellowstone Lake; Madison Valley.

Carex ampullacea, Good.—Yellowstone River.

GRAMINACEÆ.

Alopecurus alpinus, Smith.—Stinking Water Creek.—It has most of the florets awnless, and the remainder with a very short awn.

Phleum alpinum, L.—Fort Ellis to the Yellowstone; Yellowstone Lake; Falls of the Yellowstone.

Vilfa asperifolia, Nees and Meyen.—Hot Sulphur Springs.

Vilfa asperifolia, Nees and Meyen., var. *filiformis*, Thurber.—Upper Falls of the Yellowstone.

Agrostis perennans, Tuckerm.—Upper Falls of the Yellowstone.

Agrostis scabra, Willd.—Mud Springs; Yellowstone Lake; Yellowstone River.

Muhlenbergia Mexicana, Trin.—Fort Ellis to the Yellowstone.

Vaseya comata, Thurber.—Gray's Peak, Colorado Territory, *Dr. George Smith.*

Calamagrostis Canadensis, Beauv.—Yellowstone Lake.

Calamagrostis Langsdorffii, Trin.—Upper Falls of the Yellowstone.

Calamagrostis stricta, Trin.—Yellowstone Lake; Yellowstone River.

Calamagrotis sylvatica, D. C.—Lower Falls of the Yellowstone.

Eriocoma cuspidata, Nutt.—Mud Springs; Hot Sulphur Springs.

Stipa viridula, Trin.—Fort Ellis to the Yellowstone.

Aristida purpurea, Nutt.—Hot Sulphur Springs; Yellowstone Lake.

Bouteloua oligostachya, Torr.—Madison Valley; Fish Creek.

Kœleria cristata, Pers.—Pleasant Valley; Stinking Water Creek.
Graphephorum melicoides, Beauv.—Mountains south of Virginia City.
Melica poœoides, Nutt.—Hot Sulphur Springs; Yellowstone Lake.
Melica stricta, Boland.—Pleasant Valley.
Glyceria nervata, Trin.—Pleasant Valley.
Glyceria aquatica, Smith.—Upper Falls of the Yellowstone.
Catabrosa aquatica, Beauv.—Pleasant Valley.
Poa Andina, Nutt.—Stinking Water Creek; Upper Falls of the Yellowstone.
Poa arctica, R. Br.—Falls of the Yellowstone.
Poa Serotina, Ehrh.—Lower Falls of the Yellowstone.
Poa nemoralis, L. Form. (?)—Pleasant Valley; Fort Ellis to the Yellowstone.
Poa alsodes, Gray.—Yellowstone Lake.
Poa tenuifolia, Nutt.—Fort Ellis to the Yellowstone; Yellowstone Lake.
Festuca tenella, Willd.—Utah Territory.
Festuca ovina, L.—Pleasant Valley; Stinking Water Creek; Fort Ellis to the Yellowstone.
Bromus breviaristatus, Thurb., (*Ceratochloa*, Hook.)—Pleasant Valley; Mud Springs; Yellowstone Lake; Yellowstone River.
Phragmites communis, L.—Crow Agency; Spring Creek.
Triticum repens, L.—Pleasant Valley; Yellowstone Lake; Fish Creek.
Triticum caninum, L.—Pleasant Valley; Yellowstone Lake.
Triticum strigosum, Steud.—Salt Lake, Utah Territory.
Hordeum pratense, Huds.—Pleasant Valley; Yellowstone Lake.
Elymus condensatus, Presl.—Pleasant Valley; Stinking Water Creek.
Trisetum subspicatum, Beauv.—Yellowstone Lake; Falls of the Yellowstone.
Aira flexuosa, L.—Mud Springs; Yellowstone Lake; Upper Falls of the Yellowstone.
Aira cæspitosa, L.—Pleasant Valley; Mud Springs; Upper Falls of the Yellowstone.
Aira danthonioides, Trin.—Gray's Peak, Colorado Territory, *Dr. George Smith.*
Hierochloa borealis, R. and S.—Yellowstone Lake.
Phalaris arundinacea, L.—Stinking Water Creek.
Beckmannia erucæformis, Host.—Madison Valley; Fish Creek.
Panicum dichotomum, L.—Mud Springs; Yellowstone Lake.

EQUISETACEÆ.

Equisetum lævigatum, A. Br.—Pleasant Valley; Madison Valley.
Equisetum robustum, A. Br.—Hot Sulphur Springs.
Equisetum arvense, L.—Fort Ellis to the Yellowstone; Yellowstone Lake.

FILICES.

Pteris aquilina, L.—Yellowstone Lake.
Cryptogramme acrostichoides, R. Br.—Yellowstone Lake.
Cystopteris fragilis, Bernh.—Mud Springs.
Woodsia scopulina, D. C. Eaton.—Stinking Water Creek; Madison Valley.
Woodsia Oregana, D. C. Eaton.—Madison Valley.

LYCOPODIACEÆ.

Lycopodium annotinum, L.—Upper Falls of the Yellowstone.
Selaginella rupestris, Spring.—Mountains south of Virginia City.

MUSCI.

Determined by Leo Lesquereux, esq.

Sphagnum acutifolium, Ehrh.—Madison Valley.
Didymodon rubellus, W. and M.—Doane's Peak, Yellowstone Lake.
Barbula ruralis, Hedw.—Yellowstone River.
Grimmia conferta, Funk.—Yellowstone River.
Grimmia ovata, W. and M.—Yellowstone Lake.
Grimmia Scouleri, Müll.—Upper Falls of the Yellowstone.
Grimmia calyptrata, Hook.—Upper Falls of the Yellowstone.
Racomitrium heterostichum, Brid.—Madison Valley.
Racomitrium canescens, Brid., var. *ericoides*, Lesq.—Doane's Peak.
Polytrichum juniperinum, L.—Yellowstone Lake.
Aulacomnion palustre, L.—Foot of Doane's Peak.
Bryum pyriforme, L.—Foot of Doane's Peak.
Bryum intermedium, W. and M.—Yellowstone River.
Mnium punctatum, L.—Snake River.
Mnium cuspidatum, Hedw.—No locality given.
Bartramia fontana, Brid.—Foot of Doane's Peak.
Dichelyma falcatum, Myrin.—Snake River.
Climacium dendroides, W. and M.—Madison Valley.
Hypnum salebrosum, Brid., (?) sterile.—Madison Valley.
Hypnum Nevadense, Lesq.—Utah Territory.
Hypnum serpens, L., (?) sterile.—Yellowstone Lake.
Hypnum irriguum, Wils., var. *fallax*, Brid.—Soda Springs, Utah Territory.
Hypnum giganteum, Schimp.—Soda Springs, Utah Territory; between Crow Agency and Gallatin River.
Hypnum aduncum, Hedw., (?) sterile.—It may be a new species.—Turbid Lake, August 17.
Hypnum filicinum, L.—Falls of the Yellowstone.
Hypnum triquetrum, L.—Madison Valley.
Hypum ——, (?)—"It has the aspect of *H. graminifolium*, Hook., but cannot be determined for lack of fruit. It is probably a new species."

HEPATICÆ.

Marchantia polymorpha, L.—Yellowstone Lake.

LICHENES.

Determined by Prof. Edward Tuckerman.

Evernia vulpina, Ach.—Yellowstone Lake.
Usnea barbata, Fries.—Yellowstone Lake.
Alectoria Fremontii, Tuckerm.—Yellowstone Lake; Falls of the Yellowstone.
Parmelia ambigua, Ach.—Yellowstone Lake.
Umbilicaria vellea, Fries, (?) sterile.—Yellowstone Lake.
Peltigeria rufescens, Hoffm.—Hot Sulphur Springs.
Lecanora subfusca, Ach.—Yellowstone Lake.
Cladonia rangiferina, Hoffm.—Madison Valley.

PART V.

METEOROLOGY,

BY

J. W. BEAMAN.

METEOROLOGY, ETC.

BY J. W. BEAMAN.

WASHINGTON, D. C.

DEAR SIR: I take pleasure in presenting for your consideration the report of my meteorological labors, feeling that, although it is deficient in many respects, it cannot but be of some interest in answering many questions as to the climate and elevation of the interesting region which furnished the data. As you are well aware, our irregular movements in the field have their effect in overturning anything which looks toward a perfect system of observations, such as it would be gratifying to present for your approval. Nevertheless, the record has been kept with comparatively few omissions. It has been my aim to be as accurate as the character of the work would admit. To this end observations have been made at each camp with the mercurial barometer and attached thermometer; detached open-air thermometer; dry and wet bulb thermometers. The direction and force of the wind; kind and movement of cloud; the proportional amount of clear sky; special phenomena, and other data worthy of record, have been noted.

Here I desire to mention, with gratitude, the assistance afforded me, in the way of valuable advice, by Mr. Charles A. Schott, of the United States Coast Survey; also, valuable aid rendered by Mr. Fred. J. Huse, and Mr. A. Smith, of the expedition. Let me thank you, sir, for your ever generous and gentlemanly bearing toward myself.

Trusting that the accompanying report will meet your approbation, I have the honor to be, very respectfully, yours,

J. W. BEAMAN.

Dr. F. V. HAYDEN.

INTRODUCTION TO THE TABLES.

INSTRUMENTS USED IN THE METEOROLOGICAL WORK.

The barometers used were Mr. James Green's siphon-barometers, No. 1283 and No. 1363. No. 1363 had an index error of —.01″; No. 1283, +.01″. No. 1283 proved to be worthless, on account of an imperfection in the glass tube, which allowed the mercury to escape. It was refilled at Ogden, Utah Territory, but after a few days' use broke at the point of imperfection, and was set aside until we reached Fort Ellis. Here, through the kindness of Colonel J. W. Barlow, United States Engineers, we obtained a new tube, which was filled with mercury by Mr. A. Schönborn, topographer of the expedition. It did good service at Boteler's Ranch, Yellowstone Valley, during the latter part of July and nearly the whole of August. Its index error was +.015″. Soon after starting homeward it proved unreliable, from loss of mercury and admission of air. No. 1363 worked admirably, passing through the whole journey from Ogden to Fort Ellis; from Fort Ellis to Yellowstone Lake, and back; and from Fort Ellis to Fort Bridger. On comparison at the Medical Museum, Washington, D. C., with a standard barometer, its

index error was found to be — .013″, having changed in its journey of seven thousand miles only .003 of an inch, which represents about 3 feet in elevation. We made use of small aneroid barometers for taking elevations on the road, and also those of mountains. The results obtained were quite satisfactory. But without a mercurial barometer as a check they are almost worthless. Their structure is so delicate as to render them liable to permanent injury by a sudden fall, or by the constant jolting to which they are subjected when carried upon horseback. It was only with the utmost care that the one which was my constant companion was kept in good condition. Another fact noted was the sluggish return of the index to the correct reading, after having been taken to an elevation of several thousand feet. The thermometers used were those manufactured by James Green, and were small-sized Fahrenheits. Two of these were fitted to be used as wet and dry bulb thermometers, and furnished much interesting material for the record.

The distances given in the table were estimated from odometer readings, taken by Mr. A. Schönborn, of the expedition.

To the officers in charge of the U. S. Medical Museum, Washington, D. C., we are indebted for much valuable assistance in the comparison of the instruments with standards. We have made the suitable corrections in accordance with their advice.

The abbreviations used in the tables are those customary for the time of day, for the points of the compass, and for the clouds.

In the column for the force of the wind, 0 indicates a perfect calm; 1 indicates a light air; 2 indicates a pleasant breeze; 3 indicates a fresh breeze; 4 indicates a stiff breeze; 5 indicates a moderate blow; 6 indicates a light gale; 7 indicates a hard gale; 8 indicates a very heavy gale; 9 indicates a very great storm; 10 indicates a hurricane or tornado.

In the column for the amount of clear sky, 0 indicates a sky totally obscured by clouds; 10 indicates a sky perfectly free from clouds. The intermediate numbers indicate the relative amount of clouds and clear sky.

The barometric readings have been corrected for index error, and reduced to 32° Fahrenheit.

In the calculations for elevation, Loomis's tables, as given in his "Introduction to Practical Astronomy," have been employed. The morning observations at 6 o'clock, or reduced to that hour, and the evening observations at 9 o'clock, or reduced to that hour, have been preferred.

METEOROLOGICAL TABLES.

Observations taken from Ogden to Fort Ellis.

Camp of observation.	Date.	Hour of the day.	Barometric reading reduced to 32° F.	Detached thermometer.	Dry-bulb thermometer.	Wet-bulb thermometer.	Difference between wet and dry thermometer.	Direction of the wind.	Force of the wind.	Kind of clouds.	Direction of clouds.	Amount of clear sky.	Approximate elevation in feet.	Distance from camp to camp in miles.	Total distance from Ogden in miles.	General remarks.
				°	°	°	°									
Ogden, on the terrace east of the city, and 185 feet above the railroad track at the depot.	June 7	11.00 a. m.	25.565	80½	80½	58½	22	N.	1	Cir.-cu		9				Clouds low on western horizon.
	7	11.50 a. m.	25.577	80½	82	60½	21½	N.	1	Cir.-cu		9				Clouds north.
	7	12.40 p. m.	25.568	83½	83½	62½	21	W.	1	Cir.-cu		9				
	7	9.00 p. m.	25.411	62½	62½	46½	16	S. E.	1			10				
	8	8.50 a. m.	25.433	68½	68½	54½	14	S.	1	Cu.-str		9				Clouds south.
	8	11.00 a. m.	25.425	85	82½	61	21½		0	Cu.-str		9				
	8	12.00 m.	25.426	82½	82½	62½	20	W.	1	Cir.-cu		9				Clouds mostly northwest.
	8	4.00 p. m.	25.324	86½	86½	59½	27	S. W.	1	Cir.-cu		9				Clouds west on the horizon.
	9	9.00 a. m.	25.441	67½	67½	52	15½	N. N. E.	1	Cir.		7				
	9	12.30 p. m.	25.481	82½	82½	60	22½		0			10				
	9	4.15 p. m.	25.481	83½	83½	55½	28	S. E.	1			10				
	9	8.15 p. m.	25.458	64	64	53½	10½	S. E.	2			10				
	10	9.00 a. m.	25.512	69½	69½	55½	14	S.	2			10	4,517			Hazy.
Water-tank, Central Pacific Railroad, near Warm Saline Springs.	10	6.00 p. m.	25.790	82½	82½	62½	20	N.	2			10		12.04	12.04	Do.
	10	9.15 p. m.	25.755	72½	72½	54½	18	N.	1	Cir.-str		9				
	11	9.00 a. m.	25.821	72½	73	60½	12½	S.	1			10				
	11	12.15 p. m.	25.816	90½	89½	77½	12	N.	1			10				Quite smoky.
	11	3.30 p. m.	25.719	94	94	70½	23½	N. W.	2	Cu.		9				Cu. forming west and south.
	11	9.00 p. m.	25.775	76½	76½	56½	20	N. E.	2	Cir.-str		9				Smoky.
	12	7.00 a. m.	25.732	67	66	57	9		0			10	4,191			Do.
Copenhagen terrace, east of the town, Box Elder Hole.	12	4.00 p. m.	24.894	87	88½	62½	26	W.	3	Cir.-str		3		14.73	26.77	
	12	7.15 p. m.	24.847	78½	78½	61½	17	S. E.	4	Nim		0				
	12	9.45 p. m.	24.695	68	68	57	11	S. E.	1	Cu.	W.	1				
	13	5.15 a. m.	24.904	50	50	45½	4½	E.	1	Cir.-cu		9	4,999			Clouds southwest.
Cache Valley, south of Wellsville.	13	3.30 p. m.	25.417	90½	89½	55½	34	S. E.	2			10		12.89	39.66	
	13	8.45 p. m.	25.416	73½	73½	51	22½	S. W.	2			10				
	14	6.45 a. m.	25.427	52½	52½	46½	6		0			10	4,568			
Smithfield, near the bridge over Smithfield Creek, Cache Valley.	14	3.30 p. m.	25.397	94½	92½	64	28½	N. W.	2	Cu., cir.-cu		9		17.63	57.29	
	14	9.10 p. m.	25.336	75	74½	56½	18		0	Cir.-str		9				
	15	6.40 a. m.	25.392	57	57½	48½	9		0	Cir.		9	4,616			Smoky.
Grass Creek, Cache Valley	15	3.30 p. m.	25.311	95½	93½	65½	28	S. W.	1	Cu., cir.-str		9		17.43	74.72	Wind changeable.

Observations taken from Ogden to Fort Ellis—Continued.

Camp of observation.	Date.	Hour of the day.	Barometric reading reduced to 32° F.	Detached thermometer.	Dry-bulb thermometer.	Wet-bulb thermometer.	Difference between wet and dry thermometer.	Direction of the wind.	Force of the wind.	Kind of clouds.	Direction of clouds.	Amount of clear sky.	Approximate elevation in feet.	Distance from camp to camp in miles.	Total distance from Ogden in miles.	General remarks.
				°	°	°	°									
Grass Creek, Cache Valley—Con.	June 15	8.15 p. m.	25.307	72	71½	52½	19	N. E.	1	Cir.-str.		9				
	16	6.00 a. m.	25.431	57½	60½	52	8½		0			10	4,624			
Grasshopper Creek	16	3.30 p. m.	25.177	82	82	60½	21½	S. W.	1	Cir.-cu.		9		21.35	96.07	
	16	8.00 p. m.	25.242	61½	60½	47½	13		0	Cir., cir.-str.		9				
	17	6.00 a. m.	25.204	46	46½	41½	5		0			10	4,706			
Marsh Creek	17	4.40 p. m.	25.351	86½	86½	62½	24	N. W.	3	Cu.		9		21.41	117.48	
	17	8.00 p. m.	25.333	64	65	51½	13½	N. W.	1	Cir.-str., cir., cu.		9				
	18	6.30 a. m.	25.289	45¼	45½	40½	5		0	Cir.-cu., cu.-str.		3	4,626			Aurora borealis last night.
First camp on Port Neuf River	18	3.30 p. m.	25.306	90½	90½	62½	28	N. W.	1	Cir., cu.		3		14.16	131.64	
	18	8.15 p. m.	25.265	60½	60½	54½	6	S. E.	1	Cu.-str.		3				Thunder-storm passed to north.
	19	6.30 a. m.	25.348	61½	62½	55½	7	S. W.	1	Cu.-str.	E.	3	4,565			
Second camp on Port Neuf River.	19	3.45 p. m.	25.445	93	93½	63½	30		0	Cir.-cu., cu.	E.	7		16.34	147.98	Clouds mostly north.
	19	8.15 p. m.	25.417	71½	70½	53	17½	S. W.	1	Cir.-str., cu.-str.	E.	1				
	20	6.00 a. m.	25.490	65½	65½	55	10½	S.	1	Cir.-cu., cu.-str.	E.	3	4,441			Thunder-storm during the night.
Ross Fork, near the bridge	20	12.00 m.	25.414	91	92½	64½	28	S. W.	1	Cir.-str., cu.	E.	3		13.34	161.32	
	20	4.00 p. m.	25.360	88	88	62½	25½	S. W.	3	Cu., cu.-str.	S. W.	1				Thunder at a distance.
	21	9.00 a. m.	25.551	60	60½	55½	5	N.	1	Cir.-cu., cu.	N.	9	4,394			
Fort Hall	21	3.30 p. m.	25.166	89½	88½	62½	26	S.	3	Cu., cu.-str.	N. E.	1		14.68	176.00	Thunder-storm at a distance.
	21	8.15 p. m.	25.217	70½	70½	56	14½	N. E.	5	Cir.-cu., cu.-str.	N. E.	6				Wind, gusty.
	22	9.00 a. m.	25.225	77	77½	58½	19	S. W.	1	Cir., cir.-cu.		7				Sultry.
	22	10.00 a. m.	25.095	91½	90	63½	26½		0	Cu., cu.-str.		7				Cu. quite heavy.
	22	4.00 p. m.	25.152	84	83½	57	26½	S. E.	3	Nim., cu.-str.		1				Thunder-storm south-west.
	22	8.15 p. m.	25.173	67½	67½	56½	11	S. E.	3	Cu.-str., nim.		0				A gale, with rain, 5.30 p. m.
	23	9.00 a. m.	25.144	67	67	55	12		0	Cir.-cu.		7				Clouds mostly south.
	23	12.00 m.	25.142	82¾	81½	60	21½	S. W.	1	Cu.-str., nim.	S. E.	6	4,720			Thunder-storm, wind, gusty.
Blackfoot Fork, at the bridge	23	8.00 p. m.	25.246	62	61½	54½	7		0	Cu.-str., cir.-str.		2		7.20	183.20	
	24	6.15 a. m.	25.264	54¾	54½	52	2½		0	Cu.-str.	N. E.	1	4,456			

Taylor's Bridge, Snake River		24	1.00 p.m.	25.115	80½	80	64½	15½	S.	(5)	Nim., cu.-str	N. E.	1		19.85	203.05	Rain on mountains south.
		24	4.00 p.m.	25.117	70½	69½	54½	15	S.	1	Nim., cu.-str	N.	2				
		24	8.15 p.m.	25.204	56½	56½	53½	3	S.	1	Cu.-str., nim	N.	1				Rain and wind from southwest.
Market Lake		25	6.30 a.m.	25.333	56	57	51½	5½	S. W.	1	Cir.-str., cu.-str	N. E.	6	4,627			Clouds east, rising.
		25	1.30 p.m.	25.272	76	74½	54½	20	S.	3	Cir., cu., cu.-str	N. W.	2		20.04	223.09	Clouds forming northeast.
		25	7.45 p.m.	25.228	61½	61½	48½	13	S. E.	1	Cu.-str		9				
		26	6.00 a.m.	25.431	47	46½	43¼	3¼	N. E.	1	Cu., cir.-str		10	4,795			Smoky on Salmon River Mountains.
Camas Creek		26	12.45 p.m.	25.351	87½	88½	59½	29	S. W.	1	Cu., cir.-str	N.	7		17.71	240.80	
		26	4.00 p.m.	25.312	88½	88½	56	32½	S. E.	1	Nim., cir.-cu	N.	1				Thunder-storm southwest.
Dry Creek		26	7.30 p.m.	25.242	69	68½	51½	17		0	Cir.-str., cu.-str	N.	3				
		27	5.00 a.m.	25.398	57½	56½	46½	10	N. E.	1	Cu.-str., cir.-cu	N. E.	2	4,687			
		27	1.00 p.m.	24.876	85	83½	57½	26	N. E.	3	Nim., cu., cir.-str		4		18.41	259.21	Heavy cu. north.
		27	4.00 p.m.	24.903	79	79	55	24	N. W.	5	Nim., cir.-str	S. E.	2				Drops of rain; thunder distant.
Pleasant Valley		27	8.00 p.m.	24.900	66¼	66½	50½	16	N. E.	3	Cu.-str		8				Clouds clearing.
		28	5.30 a.m.	24.915	61¼	61½	51½	10	N. E.	3	Cir., cu.-str		9	5,031			
		28	1.00 p.m.	23.956	71	70½	56	14½	S.	1	Cu., cir.-str		6		16.65	275.86	Drops of rain; wind rising.
Wilson's Ranch, near the Junction.		28	4.00 p.m.	23.951	67¾	66½	52½	14	N. W.	3	Nim., cu.-str	N. E.	1				Thunder and lightning.
		28	7.45 p.m.	24.025	56	55½	49½	6	N. W.	1	Cu.-str., nim		1				Clearing shower.
		29	5.30 a.m.	24.068	49	49	44½	4½	N.	1	Cir		7	6,086			
		29	2.00 p.m.	23.691	76	74½	53½	21	W.	1	Cu	E.	9		17.75	293.61	
		29	4.00 p.m.	23.664	76	75½	50½	25	N. W.	4	Cu	E.	9				
		29	7.30 p.m.	23.669	61	60½	40½	20¼	N. W.	1	Cu.-str		9				
		30	7.00 a.m.	23.683	57	56½	44½	12	N.	1			10				Wind gusty.
		30	9.00 a.m.	23.658	75	74	60	14					10				
		30	12.00 m.	23.632	79½	79½	56½	23	W.	1			10				
		30	2.30 p.m.	23.611	77½	77½	55½	22	W.	0	Cir.-cu						
		30	4.15 p.m.	23.589	75	75½	56	19½	W.	3	Cir.-cu		9				Wind changeable.
		30	7.40 p.m.	23.618	63	62½	44½	18	N. W.	4			10				Crimson glow east horiz'n
	July	1	5.15 a.m.	23.737	42	44½	40½	4	E.	1			10	6,329			
Wildcat Creek		1	1.30 p.m.	23.053	69½	69	45½	23½	S. W.	4	Cir.-cu	S. W.	9		22.96	316.57	
		1	4.00 p.m.	23.048	70	69½	46½	23	S. W.	4	Cu., cir.-cu	W.	9				
		1	7.40 p.m.	23.043	56¼	56	42	14	N. W.	1	Cu.-str	S. W.	5				
Black-tailed Deer Creek		2	6.15 a.m.	23.100	47½	48½	39½	9	N. E.	1	Cu.-str., cir.-str		9	6,983			
		2	11.30 a.m.	24.084	68½	67½	47½	20	N. N. E.	3	Cu	S. W.	5		6.82	323.39	
		2	3.30 p.m.	24.106	74	74½	52½	22	E.	1	Cu., cir.-cu	S.	9				Wind gusty, clouds clearing.
Stinking Water River		2	8.00 p.m.	24.070	53½	52½	42½	10	S. E.	1	Cir.-str		9				Wind changeable.
		3	5.30 a.m.	24.041	53	54½	44	1¼	S. W.	1			10	5,973			
		3	12.30 p.m.	24.543	82	79½	53½	26	S. W.	2	Cir		9		18.44	341.83	Do.
		3	3.30 p.m.	24.547	81	80½	53½	27	N. W.	3	Cu., cir.-str	S.	9				
		3	8.00 p.m.	24.515	54¼	53½	44	9½	E. N. E.	1	Cir.-str., cir.-cu	N.	9				
Springs, near Virginia City		4	5.30 a.m.	24.438	44	44½	39½	5	N. W.	1	Cu.-str	E.	1	5,437			Clouds low, but rising.
		4	2.00 p.m.	23.978	77	74½	51	23½	S. W.	3	Cu.-str	S.	0		19.35	361.18	
		4	4.00 p.m.	23.962	70½	70½	50½	20	N. E.	2	Cu.-str	S.	0				
		4	7.40 p.m.	23.945	61	61	49½	11½		0	Cu.-str	E.	0				Beautiful golden glow west.

Observations taken from Ogden to Fort Ellis—Continued.

Camp of observation.	Date.		Hour of the day.	Barometric reading reduced to 32° F.	Detached thermometer.	Dry-bulb thermometer.	Wet-bulb thermometer.	Difference between wet and dry thermometer.	Direction of the wind.	Force of the wind.	Kind of clouds.	Direction of clouds.	Amount of clear sky.	Approximate elevation in feet.	Distance from camp to camp in miles.	Total distance from Ogden in miles.	General remarks.
					°	°	°	°									
Springs, near Virginia City—Con.	July	5	7.15 a. m.	24.068	59	58½	42	16½	N.	2	Cir.-cu., cu.-str	N.	9				Clouds clearing.
		5	9.00 a. m.	24.028	62½	62	47¼	14¾	W.N.W	3	Cu	W.	3				Clouds forming east.
		5	12.30 p. m.	24.036	76	78½	55½	23	W.S.W.	2	Cu	W.	4				Clouds heavy northwest.
		5	3.30 p. m.	24.032	75	74½	54	20½	W.S.W.	1	Cu	W.	5				
		5	7.40 p. m.	24.080	61½	60½	46½	14	S. W.	3	Cir		9				Clouds forming n'rthw'st.
		6	8.00 a. m.	24.145	61	62	46½	15½	N. W.	1			10				
		6	10.00 a. m.	24.079	71¼	72	53¼	18¾	W.N.W	2	Cu.-str	W.	9	5,961			Do.
First terrace above Madison River.		6	4.00 p. m.	24.850	87	87	54½	32½	S. W.	5	Cir.-str., cu	S. W.	2		10.54	371.72	
		6	7.30 p. m.	24.824	69½	68½	49¾	18¾	S. W.	2	Cu., cu.-str	S. W.	6				
		7	7.00 a. m.	24.741	71½	72½	54½	18	S. S. W.	5	Cu	N. W.	9	5,177			
Hot Spring Creek		7	3.30 p. m.	24.775	74	72½	51½	21	N. N. E.	5	Cir.-cu., cu.-str	W.	2		15.70	387.42	
		7	7.30 p. m.	24.955	51½	50½	40½	10	N. N. E.	1	Cu.-str		0				
		8	6.00 a. m.	25.087	45	44	38	6	N.	1	Cir.-cu., cu.-str	W.	1	4,804			
Elk Creek, near fork of roads		8	1.30 p. m.	25.330	58	57	51	6	N. N. E.	1	Nim		0		18.75	406.17	Rain, lasting 20 minutes.
		8	3.45 p. m.	25.277	58	56¾	46½	10¼	E.	5	Cu.-str	S.	2				Rain giving place to wind.
		8	7.30 p. m.	25.266	52	50½	42½	8	E.	5	Cu., cu.-str	S.	2				A few drops of rain.
		9	6.00 a. m.	25.463	53¼	48¾	44¼	4½		0	Str., cu	W.	9	4,438			
First camp near old saw-mill, on East Gallatin River, Fort Ellis.		9	4.30 p. m.	25.180	67	66	51½	14½	N. W.	2	Cu., cir.-cu., cu.-str	W.	8		23.75	429.92	
		9	7.30 p. m.	25.173	49½	50	44	6		0	Cir.-cu	W.	4				
		10	9.00 a. m.	25.227	72	70	60	10	N.N.W.	1			10				
Second camp near Fort Ellis, on East Gallatin River.		10	12.45 p. m.	25.226	72	72	54	18	W.	2			10				
		10	7.30 p. m.	25.181	55½	54½	46½	8	E.	2			10				
		11	8.00 a. m.	25.112	67½	68¼	54	14½	W.	1			10				
		12	9.00 a. m.	25.036	77¼	77½	64	13½	S.	1	Cir.-str		9				
		12	1.00 p. m.	24.983	82¾	83½	57¼	26¼	N.N.W.	2	Cu., cu.-str	W.	7				Storm northwest.
		12	4.30 p. m.	25.018	69	69	56	13	E. S. E.	2	Cu.-str., nim	W.	1				A few drops of rain.
		12	7.25 p. m.	25.067	61½	59	50½	8½	E. S. E.	1	Cir.-str., nim	W.	7				Very little rain.
		13	9.00 a. m.	25.216	71¾	71¾	60	11¾		0			10				
		13	12.00 m	25.204	84¼	86½	67½	19	E. S. E.	1			10				
		13	4.00 p. m.	25.160	85¼	85¾	60½	25¼	N. W.	2			10				Wind gusty & change'ble.
		13	7.25 p. m.	25.200	58½	58½	52¼	6¼	N. N. E.	1	Cir.-str		9				

Observations taken from Fort Ellis to Boteler's Ranch.

Camp of observation.	Date.	Hour of the day.	Barometric reading reduced to 32° F.	Detached thermometer.	Dry-bulb thermometer.	Wet-bulb thermometer.	Difference between wet and dry thermometer.	Direction of the wind.	Force of the wind.	Kind of clouds.	Direction of clouds.	Amount of clear sky.	Approximate elevation in feet.	Distance from camp to camp in miles.	Total distance from Fort Ellis in miles.	General remarks.
				°	°	°	°									
Second camp near Fort Ellis, on East Gallatin River—Continued.	July 14	9.00 a.m.	25.187	79½	79½	62½	17	W.S.W	2	Cir.-cu., cu.-str.	W.	1				
	14	12.00 m	25.142	88	87½	66½	21	E.	2	Cir.-cu., cu.-str.		1				
	14	4.00 p.m.	25.077	91	91¾	71½	20¼	E.	1	Cir.-cu., cu.-str.		2				
	14	7.25 p.m.	25.122	66½	66½	57½	9	E.	1	Cir.-str., cu.-str.	S.	1				
	15	6.30 a.m.	25.306	69	68½	59½	9	E.	1	Cir.-str., cir.-cu	W.	7	4,789			Clouds southwest.
Spring Creek, branch of East Gallatin River, on Indian trail.	15	4.00 p.m.	24.589	76	76½	65½	11		0	Cu	S. W.	2		9.16		
	15	7.25 p.m.	25.574	65½	64½	60	4½	S. W.	1	Nim		0				Raining briskly.
	16	5.00 a.m.	24.643	50½	50½	46	4½	S. W.	1	Cir., cu	N. E.	9	5,372			Showers during night.
Trail Creek, 80 feet above the surface of the water.	16	3.30 p.m.	24.855	67½	66½	62	4½	W.	1	Nim	W.	0		10.06	19.22	Thunder-storm; clouds heavy.
	16	7.15 p.m.	24.886	65¾	65	59½	5½	E.N.E.	3	Cu.-str	W.	0				Clouds brassy west.
	17	4.45 a.m.	24.897	54¼	54½	52½	2¼	W.	2	Cir.-cu	W.	6	5,043			Showers during night.
Boteler's Ranch, 80 feet above Yellowstone River.	17	4.00 p.m.	25.134	78	78	60	18	N. E.	1	Cu., nim	W.	4		16.03	35.25	Drops of rain falling.
	17	7.35 p.m.	25.147	66	66½	54½	12	N. W.	1	Cu		9				
	18	9.00 a.m.	25.197	83	82	64	18	N. E.	1	Cu		9				Clouds mostly north.
	18	12.00 m	25.167	87¼	86½	63	23½	N. W.	1	Cu		9				
	18	3.30 p.m.	25.129	85	85	61½	23½	N. W.	1	Cu		9				
	18	7.20 p.m.	25.107	63¾	63	52½	10½		0	Cir		7				
	19	9.00 a.m.	25.094	81¼	81	59½	21½	S. W.	3	Cir.-cu		8				Smoky on mountains.
	19	12.00 m	25.019	90¾	89½	62	27½	E.	4	Cu., cu.-str.	W.	7				
	19	4.00 p.m.	24.982	85	84½	62½	22		0	Cu.-str	W.	1				
	19	7.30 p.m.	24.982	78	77½	56½	21	N. W.	2	Cu.-str	W.	0				
	20	7.15 a.m.	25,087	67	66½	58	8½		0	Cir.-str., cu.-str.	W.	0				Clouds black east.
	20	9.00 a.m.	25.117	67½	67½	60	7½	N.	1	Nim., cu., cir.-cu.	S. S. W.	0				Rain north, south, and west.
	20	12.00 m	25.116	75	79½	69	10½	W.	2	Cir.-cu., nim	S. W.	4				
	20	3.15 p.m.	25.096	86	86½	66½	20	S. W.	2	Cu., cir.-cu	S. W.	3				
	20	7.00 p.m.	25.086	71	71½	62½	9	S. W.	1	Cir.-cu., cir.-str	S. W.	1				
	21	6.45 a.m.	25.097	68	69½	61½	8	W.S.W	1	Cir.-str., cu.-str	N.	2				
	21	9.00 a.m.	25.116	83	84½	64½	20	S.	2	Cu., cir.-cu	S. W.	3				
	21	12.25 p.m.	25.086	94¼	92½	68½	24	S.	2	Cu., cir.-cu	N. E.	2				
	21	3.00 p.m.	25.066	78	79½	64	15½	S. W.	1	Cir.-str., nim	N.	0				Slight sprinkle from southwest.
	21	6.20 p.m.	25.076	70½	70½	60½	10	S. W.	3	Cir.-cu., cir.-str.	N. E.	2				

Observations taken at Boteler's Ranch—Continued.

Camp of observation.	Date.	Hour of the day.	Barometric reading reduced to 32° F.	Detached thermometer.	Dry-bulb thermometer.	Wet-bulb thermometer.	Difference between wet and dry thermometer.	Direction of the wind.	Force of the wind.	Kind of clouds.	Direction of clouds.	Amount of clear sky.	Approximate elevation in feet.	Distance from camp to camp in miles.	Total distance from Fort Ellis in miles.	General remarks.
				°	°	°	°									
Boteler's Ranch—Continued	July 22	5.15 a. m	25.073	64½	64½	57½	7	S. S. W.	3	Cu., cu.-str	S. S. W.	0				Slight sprinkle during the night.
	22	9.00 a. m	25.054	76	76½	63½	13	S.	3	Cir.-cu., cu.-str	N. E.	3				
	22	12.00 m	25.023	90½	89½	69	20½	E. N. E.	3	Cir.-cu., nim	S. W.	4				Rain west passing east.
	22	3.00 p. m	25.016	73	69½	62	7½	W.	2	Cu.-str., nim	S. W.	0				Showers heavy south and north.
	22	7.45 p. m	25.090	61½	62	58½	3½	S.	2	Cu., cu.-str	S. W.	5				
	23	6.00 a. m	25.131	57	56½	53	3½	S.	4	Cu.-str., nim	S. S. W.	1				Rain from southeast.
	23	9.00 a. m	25.132	63½	62½	57	5½	S.	1	Cu.-str., nim	S.	1				Rain from north.
	23	12.15 p. m	25.146	87	85½	16½	19	S.	1	Cu.-str., nim	S. S. W.	3				Thunder-storm east and south.
	23	3.20 p. m	25.176	81½	80½	61½	19	S. W.	3	Cu., cir.-str	S. W.	7				
	23	7.45 p. m	25.080	62½	61½	55	6½	S. W.	1	Cu	S. W.	8				
	24	7.10 a. m	25.115	65½	65½	60½	5	S. W.	2	Cir.-str		8				
	24	10.45 a. m	25.015	86	86½	67½	19	S. W.	3	Cir.-cu., cir		9				
	24	12.30 p. m	25.002	88	86½	63	23½	S.	3	Cu	S. W.	9				
	24	3.15 p. m	25.021	82	82	57	25	S.	3	Cu., cir.-cu	S. W.	5				
	24	6.50 p. m	25.004	72½	72	53½	18½	S.	4	Cu.-str., cu	S.	1				
	25	7.05 a. m	25.137	56½	62½	53½	9	S. W.	1	Cu		9				
	25	12.25 p. m	25.049	86½	86	61	25	W. S. W	2	Cu., cir.-cu	S. W.	7				
	25	3.50 p. m	25.008	77	73½	54	19½	N. E.	2	Cu., cir.-cu	S. S. W.	6				
	25	8.05 p. m	25.041	56	56½	48½	8	S. E.	1			10				
	26	5.50 a. m	24.973	49½	49½	44½	5	S. W.	1			10				
	26	9.00 a. m	24.939	68½	67	54	13	N. E.	1			10				
	26	3.10 p. m	24.817	85½	82½	57½	25	S. W.	4	Cu	S. W.	5				
	26	7.25 p. m	24.805	69½	69	53	16	W. S. W	1	Cir		9				
	27	5.15 a. m	24.714	47½	49	44½	4½	W. S. W	2	Cu., cir	S. W.	9				Heavy wind, and rain at night.
	27	9.00 a. m	24.771	87	88	66½	21½	S. W.	2			10				
	27	12.10 p. m	24.816	92	92	61½	30½	S. W.	4	Cu	S. W.	9				
	27	3.00 p. m	24.701	93	88	58	30	S. W.	4	Cu	S. S. W.	7				
	27	7.15 p. m	24.684	74	73½	51½	22	S. S. W.	4	Cu.-str., nim	S. S. W.	4				
	28	6.30 a. m	24.888	62½	66½	52½	14	W. S. W.	4	Cu., cir.-cu	S. W.	8				
	28	9.10 a. m	24.884	76	77½	59	18½	S. S. W.	4	Cu., cir.-cu	W.	5				

	28	12.30 p. m.	24.897	87½	86	63	23	S. S. W.	4	Cir.-cu., cu.-str.	W.	4				
	28	3.15 p. m.	24.885	76	74½	56	18½	S. S. W.	4	Cu.-str., cu.	W.	3				
	28	6.55 p. m.	24.897	68	67½	55½	12	S. S. W.	3	Cu.-str., cu.		8				
	29	7.45 a. m.	25.160	74½	79	60½	18½	N. E.	1	Cu., cir.	S.	9				
	29	9.10 a. m.	25.166	73½	80	61½	18½	E.	1	Cir.-cu		9				
	29	12.00 m	25.107	86	86½	65½	21	N. E.	2	Cu	S. S. W.	8				
	29	2.15 p. m.	25.081	86	84	64½	19½	N. E.	2	Cir.-cu., cu.	N. E.	7				
	29	8.30 p. m.	25.062	62½	61½	53½	8	N.	2	Cu., cir.		8				
	30	6.00 a. m.	25.049	57	59	52½	6½	S. W.	1	Cu., cu.-str.	N. W.	7				
	30	9.00 a. m.	25.047	81	82½	58	24½	S. S. W.	3	Cu., cu.-str.		6				
	30	12.00 m	25.005	93	93½	64½	29	S. W.	4	Cu., cir.-cu.	S. W.	8				
	30	2.45 p. m.	24.983	81½	82½	56	26½	S. W.	4	Cu	W.	8				
	30	7.30 p. m.	24.980	71½	70	54½	15½	W.	1			10				
	31	6.30 a. m.	25.011	67	72½	55½	17	S. S. W.	3			10				
	31	9.25 a. m.	25.004	91	91½	62½	29	S. S. W.	3			10				
	31	12.15 p. m.	24.985	91½	94	63½	30½	S. S. W.	4			10				
	31	3.00 p. m.	24.964	93½	92½	60½	32	S. S. W.	4	Cu		9				
	31	7.45 p. m.	24.964	68½	66½	51½	15	S. W.	1			10				
Aug.	1	7.20 a. m.	24.996	73	74	53½	20½	S.	1			10				
	1	9.15 a. m.	24.998	80	80½	57	23½	S.	3			10				
	1	12.00 m	25.006	86½	84½	60½	24	S.	4	Cu	S. W.	9				
	1	4.00 p. m.	24.989	80½	79	58½	20½	S. W.	3	Cu., cir.-cu.	W. S. W	8				
	1	7.15 p. m.	24.994	68	65½	50½	15	S. W.	2	Cu	S. W.	6				
	2	6.45 a. m.	25.118	56	61	52½	8½	W.	2			10				
	2	7.30 p. m.	25.081	70½	70½	51	19½	N.	3	Cu., cir.-str.	S. W.	5				
	3	7.00 a. m.	25.190	57	57	50	7	N. W.	1	Cu.-str	S. W.	1				
	3	9.20 a. m.	25.132	83	82½	62½	20	N. W.	3	Nim., cu.-str.	N.	2				
	3	12.15 p. m.	25.184	72½	71	54½	16½	N. E.	3	Cir.-cu., cu.-str.	N. E.	4				
	3	3.00 p. m.	25.184	74	71	55½	15½	N. E.	1	Cu.-str., nim	N. N. E.	1				Sprinkle 1.30 p. m. Heavy rain 3 p. m.
	3	7.20 p. m.	25.113	55½	55	48½	6½	N. E.	2	Cu., cir.-cu.		4				
	4	8.10 a. m.	25.228	70	72	61½	10½	E.	1	Cir.-cu., cu.	N. W.	8				
	4	9.30 a. m.	25.228	76	76½	63½	13	S. W.	2	Cu	N. W.	8				
	4	12.00 m	25.197	85	84½	59½	25	N. E.	2	Cir.-cu., cu.	S. W.	9				
	4	4.00 p. m.	25.166	79½	79½	58	21½	N. E.	3	Cu	N.	9				
	4	8.20 p. m.	25.153	56½	57	48½	8½	N.	1	Cu., cir.-cu.		8				
	5	9.25 a. m.	25.171	83	84½	66½	18	N. W.	2	Cu	N. E.	9				
	5	1.00 p. m.	25.116	94½	95½	74	21½	S. W.	2	Cu.-str., cir.-cu.	N. W.	5				
	5	3.00 p. m.	25.106	93	85½	60½	25	S. W.	2	Cu., cir.-cu.	E.	4				
	5	8.00 p. m.	25.042	63	62½	54½	8	W.	1	Cu., cir.-cu.		6				
	6	7.30 a. m.	25.033	64	64½	53½	11	S. W.	3	Cu.-str., nim	S. W.	2				Sprinkling.
	6	9.30 a. m.	25.036	70	70	56½	13½	S. S. W.	3	Cir.-cu., cu.-str.	S. S. W.	1				
	6	12.25 p. m.	24.954	90½	88	66	22	S. S. W.	3	Cu.-str., nim	S. S. W.	3				
	6	3.00 p. m.	24.958	83½	81	62½	18½	S. S. W.	3	Cu., cu.-str.	S. W.	1				
	6	5.15 p. m.	24.979	61½				N. E.	7	Nim	N. E.	0				Rain and hail.
	6	7.30 p. m.	25.021	55½	54½	51½	3	N.	1	Cir.-cu		9				
	7	7.00 a. m	25.164	64½	66½	57½	9	N.	1	Cu		9				
	7	9.00 a. m.	25.152	73½	74½	58½	16	N. E.	2	Cu	S. W.	8				
	7	12.10 p. m.	25.017	86½	87½	65½	22	N. E.	2	Cir.-cu., cu.	S. W.	8				
	7	3.00 p. m.	25.086	90	90½	68	22½	S. S. W.	2	Cu	N. N. W	7				
	7	7.30 p. m.	25.047	69½	69	55½	13½	N. E.	1	Cu	S. S. W.	9				
	8	6.00 a. m.	25.058	61½	61	52½	8½	S. W.	1	Cir.-str	S. S. W.	9				
	8	9.00 a. m.	25.127	67½	68½	57	11½	S. S. W.	3	Cu., cir.-cu.	S. S. W.	7				

Observations taken at Boteler's Ranch—Continued.

Camp of observation.	Date.	Hour of the day.	Barometric reading reduced to 32° F.	Detached thermometer.	Dry-bulb thermometer.	Wet-bulb thermometer.	Difference between wet and dry thermometer.	Direction of the wind.	Force of the wind.	Kind of clouds.	Direction of clouds.	Amount of clear sky.	Approximate elevation in feet.	Distance from camp to camp in miles.	Total distance from Fort Ellis in miles.	General remarks.
				°	°	°	°									
Boteler's Ranch—Continued	Aug. 8	12.00 m	25.039	87	88	63	25	S. S.W.	3	Cu	S. W.	5				
	8	3.00 p. m.	25.001	86½	86½	62½	24	S. W.	1	Cir.-cu., cu	S. W.	4				
	8	7.00 p. m.	24.930	76	75½	60½	15	W.	1	Cu	W.	8				
	9	7.20 a. m.	24.917	67	68½	53½	15	W.	4	Nim., cu.-str	W.	3				
	9	9.10 a. m.	24.931	68½	68½	56½	12	S. W.	3	Cir.-cu., cu.-str	S. W.	4				
	9	12.25 p. m.	24.843	83	81½	58½	23	S. W.	5	Cu., cu.-str	W.	2				
	9	3.30 p. m.	24.869	60	60½	54½	6	E.	7	Cu.-str	E.	0				
	9	7.00 p. m.	25.123	48	46¼	43¼	3	E.	3	Cu., Cu.-str	S. W.	3				Rain from 5.30 to 6.30 p. m.
	10	8.30 a. m.	25.185	55	54½	43½	11	S. W.	4			10				
	10	12.00 m	25.125	73½	74½	56½	18	S. W.	3			10				
	10	3.15 p. m.	25.057	78½	76½	52½	24	S. W.	4	Cu., cir.-cu	S. S. W.	3				
	10	7.10 p. m.	25.045	68½	68½	53½	15	S. W.	3	Cir.-cu., cu.-str		5				
	11	9.15 a. m.	24.891	77½	80½	52½	28	S.	4	Cu., cir.-cu	W.	9				Clouds mostly west.
	11	12.15 p. m.	24.852	84½	85½	56	29½	S. W.	5	Cu.-str., cir.-cu	W.	1				
	11	3.45 p. m.	24.831	79½	78½	54½	24	S. W.	4	Cu.-str., cir.-str	W.	1				Clouds very black, west.
	11	7.30 p. m.	24.855	72½	72½	52½	20	S. W.	3	Cir.-str., cu.-str	W.	0				Nim. east.
	12	9.45 a. m.	25.257	....	70½	52½	18	S.	2	Cir.-str., cu.-str	W.	0				
	12	12.15 p. m.	25.203	....	67½	43½	24	S.	3	Cir.-cu., cu	W.	1				
	12	4.30 p. m.	25.251	....	65¼	54	11½	N. W.	2	Nim., cir.-cu	W.	3				Rain from 2 to 3.30 p. m.
	12	7.30 p. m.	25.208	....	41½	34½	7	N. W.	2	Cir.-cu		9				
	13	9.15 a. m.	25.210	....	67	48	19	S. W.	3			10				
	13	12.15 p. m.	25.212	....	77	49	28	S. E.	3	Cir		9				
	13	3.45 p. m.	25.122	....	81	51	30	S. W.	3	Cir		9				
	13	7.00 p. m.		....	68½	39½	29	S. E.	2	Cir		9				Readings of barometer incorrect.
	14	9.00 a. m.		....	76	48½	27½	S. W.	4	Cir.-cu., cir.-str	W.	7				
	14	12.00 m		....	86	52½	33½	S. W.	4	Cir.-cu., cu.-str	W.	5				
	14	3.30 p. m.		....	78½	51½	27	S. W.	3	Cir.-cu., cu.-str	W.	0				
	14	7.00 p. m.		....	67	55	12	N.	1	Cir., cir.-cu.,	W.	9				
	15	9.00 a. m.		....	60½	42½	18	N. E.	2			10				
	15	12.15 p. m.		....	71½	53	18½	N. E.	2	Cir.-cu	W.	9				
	15	4.15 p. m.		....	78	54½	23½	N. E.	3	Cir.-cu., cu	W.	9				
	15	7.00 p. m.		....	66½	49½	17	N. E.	2	Cir.-cu	W.	9				

16	10.15 a. m.	....	....	67	51½	15½	E.	1	....	....	10	......	......	....	
16	12.00 m	25.275	....	79½	56½	23	E.	2	....	....	10	......	......	....	Smoky.
16	3.00 p. m.	25.273	....	87¾	59½	28¼	E.	2	Cir	....	9	......	......	....	
16	7.30 p. m.	25.260	....	70½	52½	18	N. E.	1	Cir	....	9	......	......	....	
17	9.00 a. m.	25.235	....	76½	56½	20	W. S. W	2	....	....	10	......	......	....	Smoky on the mountains.
17	12.00 m	25.158	....	92½	60½	32	N. E.	2	Cir.-str	S. W.	6	......	......	....	
17	3.15 p. m.	25.075	....	97	59½	37½	S. W.	2	Cir.-cu., cu	S. W.	7	......	......	....	Very smoky.
17	7.00 p. m.	25.076	....	73½	50½	23	....	0	Cu.-str	....	0	......	......	....	
18	9.00 a. m.	25.072	....	80½	51½	29	W.	4	Cir.-cu., cir.-str	W.	9	......	......	....	Very smoky on mountains.
18	12.30 p. m.	25.047	....	84½	51½	33	W.	4	Cir.-str	....	9	......	......	....	Very smoky.
18	4.15 p. m.	25.076	....	85	53	32	W.	4	Cir.-str., cu	....	9	......	......	....	Do.
18	7.40 p. m.	25.062	....	70½	48	22½	N. W.	2	Cir.-str	....	9	......	......	....	Do.
19	9.00 a. m.	25.139	....	65	46½	18½	S. S. E.	1	Cir., cir.-str	....	9	......	......	....	Smoky.
19	12.00 m	25.075	....	73	53	20	E. N. E.	1	Cir.-str., cu.-str	....	0	......	......	....	Do.
19	3.00 p. m.	25.020	....	72	54	18	S. W.	5	Cir.-str., cir.-cu	S. W.	0	......	......	....	Smoky east.
20	9.15 a. m.	25.036	....	68¾	52½	16¼	W. S. W.	4	....	....	10	......	......	....	
20	12.00 m	24.971	....	85	56½	28½	S. W.	3	Cir.-cu	W.	7	......	......	....	
20	3.15 p. m.	24.953	....	89½	61	28½	S. W.	2	Cu., cu.-str	W.	2	......	......	....	Clouds very black south.
20	6.55 p. m.	24.996	....	70½	52½	18	N. N. E.	1	Cir., cir.-str	W.	1	......	......	....	
21	9.00 a. m.	25.215	....	59½	42½	17	N. E.	1	....	....	10	......	......	....	Smoke settled in bottoms.
21	12.00 m	25.112	....	71½	48½	23	N. E.	2	Cir., cir.-str	....	9	......	......	....	Smoky east.
21	3.30 p. m.	25.114	....	72½	49½	23	E. N. E.	2	Cir.-str., cir.-cu	....	9	......	......	....	
21	6.50 p. m.	25.135	....	61½	43½	18	N.	1	Cir.-cu	W.	9	......	......	....	Smoky, wind changeable.
22	9.00 a. m.	25.292	....	63	46½	16½	S. E.	1	....	....	10	......	......	....	Smoky.
22	12.15 p. m.	25.250	....	72	47½	24½	E.	1	....	....	10	......	......	....	Do.
22	4.15 p. m.	25.209	....	79	50½	28½	N. W.	2	....	....	10	......	......	....	Do.
22	6.50 p. m.	25.219	....	61½	42½	19	N. E.	1	....	....	10	......	......	....	Do.
23	9.30 a. m.	25.141	....	62½	46½	16	E.	1	Cir., cu.-str	....	1	......	......	....	
23	12.00 m	25.199	....	72½	53	19½	N. E.	1	Cir.-str	....	0	......	......	....	
23	4.30 p. m.	25.131	....	76	56½	19½	N. E.	2	Cir.-str	....	0	......	......	....	
23	7.00 p. m.	25.140	....	67½	47	20½	N. E.	2	Cir.-str., cir.-cu	N.	0	......	......	....	
24	9.00 a. m.	25.215	....	64	47½	16½	W.	2	....	....	10	......	......	....	Smoky east.
24	1.00 p. m.	25.134	....	79	53½	25½	E.	2	Cir.-cu	....	9	......	......	....	Do.
24	4.30 p. m.	25.120	....	82	53½	28½	N. N. E.	2	....	....	10	......	......	....	Very smoky east.
24	7.15 p. m.	25.115	....	59¾	45½	14¼	W.	1	....	....	10	......	......	....	Do.
25	9.00 a. m.	25.115	....	69½	50½	19	W. S. W.	3	....	....	10	......	......	....	Very smoky.
25	12.00 m	25.038	....	82½	55	27½	S. S. W.	3	Cu., cir.-cu	S. W.	3	......	......	....	Do.
25	4.15 p. m.	25.080	....	75	53½	21½	S. W.	2	Cir., cu.-str	S. W.	0	......	......	....	Clouds black northwest.
25	7.15 p. m.	25.046	....	68½	50½	18	W. S. W.	1	Cir., cu.-str	S. W.	0	......	......	....	Clouds black on the zenith.
26	9.00 a. m.	25.003	....	58	49½	8½	S. W.	1	Cir.-str	....	0	......	......	....	Rain during the night.
26	12.00 m	25.001	....	62½	55	7½	....	0	Cir., cu.-str	....	0	......	......	....	Shower from 9 to 10 a. m.
26	7.00 p. m.	25.126	....	58½	46½	12	N.	3	Cir., cu.-str	W.	0	......	......	....	
27	9.00 a. m.	25.167	....	60½	47½	13	S. W.	3	Cir.-cu., cir.-str	N.	6	......	......	....	
27	12.30 p. m.	25.176	....	74	55	19	N. E.	3	Cir.-cu., cir.-str	N.	6	......	......	....	
27	4.45 p. m.	25.171	....	76½	55	21½	N.	1	Cu.-str., cir.-cu	N.	9	......	......	....	Clouds mostly northwest.

Observations taken on the Yellowstone Lake trip.

Camp of observation.	Date.	Hour of the day.	Barometric reading reduced to 32° F.	Detached thermometer.	Dry-bulb thermometer.	Wet-bulb thermometer.	Difference between wet and dry thermometer.	Direction of the wind.	Force of the wind.	Kind of clouds.	Direction of clouds.	Amount of clear sky.	Approximate elevation in feet.	Distance from camp to camp in miles.	Total distance from Fort Ellis in miles.	General remarks.
				°	°	°	°									
Boteler's Ranch, 80 feet above Yellowstone River.	July 20	7.15 a.m.	25.107	67	66½	58	8½		0	Cir.-str., cu.-str.	W.	0	4,925			
Camp in first cañon south of Boteler's Ranch.	20	3.00 p.m.	24.981	81½				S. W.	1	Cir.-str., cir.-cu.	W.	5		13.47	48.72	
	20	7.45 p.m.	24.946	73				S.S.E.	2	Cu.-str	W.	0				
Hot Springs, White Mountains.	21	5.10 a.m.	25.015	65				S.	3	Cu.-str.		0	5,012			
	21	4.15 p.m.	23.959	60½				S.	2	Nim	W.	0		18.28	67.00	
	21	7.20 p.m.	23.939	59				S.	2	Cir.-str., cir	W.	0				
	22	9.00 a.m.	23.905	66¾				E.S.E.	2	Cir.-cu., cu.-str.	S. W.	1				Showers at night.
	22	1.45 p.m.	23.857	76				W.S.W.	4	Cu.-str., cir.-cu.	W.	3				Thunder-storm coming.
	22	4.00 p.m.	23.867	60¼				S.	4	Cu.-str., nim	S. W.	0				Shower passed to S. E.
	22	7.20 p.m.	23.898	60				W.S.W.	2	Cu.-str., cir.-cu.	W.	0				Showers from S. E.
	23	8.15 a.m.	23.948	63				S. W.	1	Cir.-cu., cu.-str.	W.	2				Showers at night.
	23	12.30 p.m.	23.918	72⅓				E. S. E.	4	Nim., cu.-str.	W.	4				Rain from 8.30 to 10 a. m.
	23	4.00 p.m.	23.943	68½					0	Cir.-str., cir.-cu.	S. W.	4				Storm in the S. E.
	23	7.20 p.m.	23.907	59¼				S. W.	1	Cir., cu	W.	8				
	24	6.00 a.m.	23.963	47				S. W.	1	Cir., cir.-str.		9	6,084			
Camp on Small Creek near Yellowstone River bridge.	24	7.20 p.m.	23.912	61				W.	1	Cu.-str., cu.	W.	7		14.11	81.11	
	25	8.00 a.m.	23.992	61⅓				N.	1			10	6,071			Smoky east.
Tower Creek, on Yellowstone Lake trail.	25	3.30 p.m.	23.661	78					0	Cu., cir.-cu.	W.	8		3.92	85.03	
	25	7.15 p.m.	23.648	61					0	Cir.-cu	W.	9				
	26	7.00 a.m.	23.643	49				S. W.	1	Cir.-cu	W.	8	6,397			
Cascade Creek, 1½ miles north of lower falls, Yellowstone River.	26	3.30 p.m.	22.413	72⅓				S. W.	4	Cir.-cu., cu.	W.	7		13.45	98.48	
	26	7.15 p.m.	22.403	60				S. W.	1	Cir.-str., cir.-cu.	S.	9				
	27	6.00 a.m.	22.445	42				E.	1	Cir.-cu.	S. W.	5	7,787			Frost at night.
Mud volcanoes, 20 feet above Yellowstone River.	27	3.15 p.m.	22.421	73½				S. W.	3	Cir.-cu., cu.	S.	9		13.62	112.10	
	27	7.30 p.m.	22.469	60				N. E.	3			10				
	28	6.00 a.m.	22.595	42½				N. E.	3	Cir.-cu., cu.-str.	W.	6	7,438			Showers during the night.
First camp on Yellowstone Lake, 14 feet above the surface of the water.	28	12.45 p.m.	22.582	59				S.	3	Cu., cir-cu	S. W.	5		6.70	118.80	
	28	3.30 p.m.	22.646	60¾				S.	3	Cir.-cu., cu.	S. W.	6				
	28	7.15 p.m.	22.648	56				N. W.	1	Cir.-cu., cu.-str.	S. W.	8				
	29	8.00 a.m.	22.729	51				S. E.	1	Cir.-cu.	S. W.	6				
	29	12.00 m.	22.696	70				S. E.	3	Cu., cir.-cu.	S. W.	5				
	29	3.30 p.m.	22.682	68½				S. S. E.	2	Cu., cu.-str.	S. E.	5				

		29	7.15 p.m.	22.700	64				S.E.	3	Cu.-str., cu.	S.W.	8				Storm in the northeast.
		30	9.30 a.m.	22.722	64				S.S.E.	2	Cu.-str., cir.-cu.		6.5				
		30	7.15 p.m.	22.682	65				S.S.E.	1			10				
		31	6.45 a.m.	22.684	50½				N.N.E.	1	Cir.-cu.	S.W.	4				
		31	12.20 p.m.	22.643	68½				S.S.E.	3	Cu.-str., cu.	S.W.	8				
		31	2.30 p.m.	22.650	71				S.S.E.	3	Cu., cir.-cu.	S.W.	8				
		31	8.00 p.m.		60½				W.	2			10				Smoky north.
	Aug.	1	9.00 a.m.	22.679	56½				N.W.	3			10				Wind gusty and changeable.
		1	12.00 m.	22.673	61½				S.W.	3			10				
		1	3.30 p.m.	22.679	67½				S.W.	3	Cu., cir.-cu.	S.W.	9				
		1	7.10 p.m.	22.688	56¾				S.W.	2			10				
		2	8.00 a.m.	22.649	50½				N.E.	2			10	7,492			
Second camp on Yellowstone Lake, 8 feet above the surface of the water.		2	7.10 p.m.	22.748	55				S.W.	1			10				
		3	7.30 a.m.	22.747	50				N.W.	1	Cir.-cu., cu.-str.	S.W.	8	7,393			
		3	12.30 p.m.	22.744	67				S.E.	2	Cir.-cu., nim	S.W.	2				Rain for ten minutes.
Third camp on Yellowstone Lake, 10 feet above the surface of the water.		3	4.00 p.m.	22.735	61				S.W.	1	Cu., nim	S.W.	1				
		3	7.30 p.m.	22.803	53½				S.W.	1	Cu., nim	S.W.	2				A few drops of rain.
		4	7.00 a.m.	22.772	44½				N.W.	1			10	7,345			Distant thunder during the night.
Fourth camp on Yellowstone Lake, south of the Hot Springs. 10 feet above the surface of the lake.		4	9.00 a.m.	22.805	58				N.N.E.	1	Cir.-cu., cu.	S.W.	1				Smoky over the lake.
		4	12.00 m.	22.803	50				S.W.	4	Cu., nim.	S.W.	0				Storm of wind, and rain from southwest.
		4	3.30 p.m.	22.780	63				N.	2	Cu., cir.-cu.		1				Wind changeable.
		4	7.30 p.m.	22.775	54				W.N.W	1	Cir.-cu., cu.-str.	N.E.	1				Clouds black in the northeast.
		5	9.00 a.m.	22.793	55				N.N.E	2	Cu., cir.-str.		9				
		5	12.30 p.m.	22.781	65½				N.E.	1	Cir.-cu., cu.-str.	S.W.	2				Clouds heavy south.
		5	3.00 p.m.	22.732	70				N.E.	2	Cir.-cu., cu.-str.	S.E.	2				Clouds heavy southeast and northwest.
		5	7.05 p.m.	22.714	56				N.E.	4	Nim., cir.-cu.	S.E.	2				Sun shower at 6 p.m.
		6	9.00 a.m.	22.666	55½				N.E.	1	Cir.-cu., cu.-str.	S.	1				Rain, in drops, 5 a.m.
		6	12.30 p.m.	22.616	71				W.N.W	2	Cu., cu.-str.	W.	3				Clouds black north and southeast.
		6	3.30 p.m.	22.585	72				N.W.	3	Cu., cu.-str.	W.	6				Wind gusty.
		6	7.30 p.m.	22.654	59				N.E.	3	Cir.-cu., nim	W.	3				Drops of rain.
		7	9.30 a.m.	22.782	63½				N.W.	3	Cu., cir.-cu.	N.W.	9				
		7	12.30 p.m.	22.764	69¾				N.W.	2	Cu., cir.-cu.	N.W.	9				
		7	3.00 p.m.	22.758	74				N.E.	2	Cu., cir.-cu.	N.W.	9				
		7	7.30 p.m.	22.769	53				S.W.	1			10				
		8	8.00 a.m.	22.733	55				N.	1			10				
		8	12.00 m.	22.714	73½				W.S.W.	2	Cu.	E.N.E.	9				
		8	7.00 p.m.	22.643	57½					0	Cu.		9				
		9	9.00 a.m.	22.566	64				S.	3	Cu., nim.	N.E.	0				
		9	12.00 m.	22.569	58½				S.W.	3	Nim.	E.	0	7,497			
Camp before Red Mountain		9	7.00 p.m.	22.616	52½				S.	3	Cu.	E.	3				Thermometer at sunrise 14°.
		10	8.00 a.m.	22.784	43				S.	1			10				
		10	1.30 p.m.	22.728	62½				S.	1	Cu.	E.	9	7,443			
Camp at head of Snake River		10	7.00 p.m.	22.550	52				S.W.	1			10				
		11	8.00 a.m.	22.460	61				S.	1			10	7,691			
Camp on Bridger River		11	7.06 p.m.	22.597	54				S.	3	Nim.	S.E.	0				Raining.
		12	8.00 a.m.	22.595	42				S.W.	3	Nim.	N.N.E.	0	7,585			Do.

Observations taken on the Yellowstone Lake trip—Continued.

Camp of observation.	Date	Hour of the day	Barometric reading reduced to 32 F.	Detached thermometer.	Dry-bulb thermometer.	Wet-bulb thermometer.	Difference between wet and dry thermometer.	Direction of the wind.	Force of the wind.	Kind of clouds.	Direction of clouds.	Amount of clear sky.	Approximate elevation in feet.	Distance from camp to camp in miles.	Total distance from Fort Ellis in miles.	General remarks.
				°	°	°	°									
Camp on terrace, Yellowstone Lake, 80 feet above the surface of the water.	Aug. 12	3.45 p. m.	22.534	50	.....	.....	.....	S. W.	3	Cu., nim	E.	5	.....	.....	.....	Snow-squalls.
	12	7.00 p. m.	22.563	42	.....	.....	.....	W.	3	Cu.	N.	9	.....	.....	.....	
	13	8.00 a. m.	22.649	43	.....	.....	.....	S. W.	1	.....	.....	10	.....	.....	.....	Heavy frost last night.
	13	12.00 m.	22.599	66	.....	.....	.....	W.	3	.....	.....	10	.....	.....	.....	
	13	3.00 p. m.	22.575	67	.....	.....	.....	W.	3	.....	.....	10	.....	.....	.....	
	13	7.00 p. m.	22.609	55	.....	.....	.....	N. W.	1	.....	.....	10	.....	.....	.....	
	14	8.00 a. m.	22.583	57	.....	.....	.....	S.	1	.....	.....	10	7,470	.....	.....	
Camp Hovey, on Yellowstone Lake.	14	4.00 p. m.	22.620	65⅓	.....	.....	.....	W.	5	Cu.	E.	9	.....	.....	.....	
	14	6.55 p. m.	22.657	59¼	.....	.....	.....	W.	3	Cu.	E.	9	.....	.....	.....	
	15	8.00 a. m.	22.838	59½	.....	.....	.....	W.S.W.	1	.....	.....	10	.....	.....	.....	Hazy.
	15	5.00 p. m.	22.870	65	.....	.....	.....	N.	3	.....	.....	10	.....	.....	.....	
	15	6.55 p. m.	22.860	49	.....	.....	.....	N.	1	.....	.....	10	.....	.....	.....	
	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	No observations.
	17	6.45 a. m.	22.962	33⅓	.....	.....	.....	W.	1	.....	.....	10	.....	.....	.....	
	17	9.00 a. m.	22.941	63½	.....	.....	.....	S.	1	.....	.....	10	.....	.....	.....	
	17	12.15 p. m.	22.874	83	.....	.....	.....	S.	1	.....	.....	10	.....	.....	.....	
	17	3.00 p. m.	22.838	76⅓	.....	.....	.....	S.	2	Cu.	S.	9	.....	.....	.....	
	17	6.50 p. m.	22.819	72½	.....	.....	.....	S.	1	.....	.....	10	.....	.....	.....	
	18	7.00 a. m.	22.781	60½	.....	.....	.....	SW.	1	Cir.-cu., cu.-str.	W.	4	.....	.....	.....	
	18	6.50 p. m.	22.769	73½	.....	.....	.....	S.	1	.....	.....	10	.....	.....	.....	
	19	5.15 a. m.	22.765	23½	.....	.....	.....	N. E.	1	.....	.....	10	7,358	.....	.....	
Earthquake camp, near Steamboat Point, 75 feet above Yellowstone Lake.	19	12.00 m.	22.687	62⅓	.....	.....	.....	S. E.	3	.....	.....	10	.....	.....	.....	
	19	3.00 p. m.	22.721	56½	.....	.....	.....	S. E.	1	Cir.-str.	.....	0	.....	.....	.....	
	19	6.50 p. m.	22.667	49	.....	.....	.....	S. E.	3	Cir.-cu., cir.	.....	8	.....	.....	.....	
	20	7.00 a. m.	22.697	44	.....	.....	.....	.....	0	.....	.....	10	.....	.....	.....	
	22	3.45 p. m.	22.781	67⅓	.....	.....	.....	S.	.....	.....	.....	10	.....	.....	.....	
	22	6.45 p. m.	22.787	57⅓	.....	.....	.....	.....	0	.....	.....	10	.....	.....	.....	
	23	5.20 a. m.	22.816	39	.....	.....	.....	N. E.	1	Cir.	S. E.	8	7,304	.....	.....	
Lake on the divide between Yellowstone Lake and East Fork of Yellowstone River.	23	3.30 p. m.	21.332	62⅓	.....	.....	.....	N.N.W.	1	Cu., cu.-str.	W.	1	.....	.....	.....	Hazy
	23	7.00 p. m.	21.824	55½	.....	.....	.....	N. W.	1	Cir.-cu.	W.	0	.....	.....	.....	
	24	6.00 a. m.	21.843	37½	.....	.....	.....	N.	1	.....	.....	10	8,470	.....	.....	
Camp on the left branch of the East Fork of Yellowstone River.	24	3.30 p. m.	23.662	73⅓	.....	.....	.....	W.	2	Cu.	W.	8	.....	.....	.....	
	24	6.40 p. m.	23.667	60	.....	.....	.....	W.	1	.....	.....	10	.....	.....	.....	
	25	6.00 a. m.	23.739	43⅓	.....	.....	.....	W.	1	Cu.	S. W.	7	.....	.....	.....	

		25	9.45 a. m.	23.693	66½	....	....	....	W.	1	....	....	10	....	....	....	Smoky.
Camp near Yellowstone bridge		25	12.00 m	23.666	74½	....	....	....	W.	3	Cu	S. W.	6	6,337	....	....	
		26	6.00 a. m.	23.894	45	....	....	....	S. W.	1	Cu.-str., cir.-cu	S. W.	5	6,071	....	....	Hazy, slight sprinkle 4 a. m.
First creek north of Gardiner's River, 50 feet above Yellowstone River.		26	6.40 p. m.	24.932	59½	....	....	....	N.	1	Cu., cu.-str	W.	2	....	....	....	
		27	5.25 a. m.	24.887	42½	....	....	....	S. E.	1	Cu., cir.-cu	N. E.	6	5,017	....	....	

Observations taken from Boteler's Ranch to Fort Bridger.

Boteler's Ranch, 80 feet above Yellowstone River.		27	6.45 p. m.	25.179	64½	63½	51	12½	....	0	Cir.-cu., cir.-str.	N.	9	....	....	....	
	Aug.	28	9.00 a. m.	25.170	72	71½	52	19½	S. W.	3	Cir.-str., cir.-cu.	....	2	....	....	....	
		28	12.00 m	25.127	84	83½	53½	30	W.S.W.	5	Cir., cir.-str	W.S.W.	2	....	....	....	
		28	4.00 p. m.	25.069	85	84½	60½	24	W.S.W.	4	Cir.-cu	W.	6	....	....	....	
		28	6.40 p. m.	25.117	74½	74½	57	17½	W.N.W	3	Cir.-cu	W.N.W	8	....	....	....	
		29	7.15 a. m.	25.332	54½	52½	45½	7	....	0	....	....	10	4,925	....	....	
Trail Creek, near Gallatin and Yellowstone River divide.		29	6.30 p. m.	24.628	....	52½	45½	7	....	0	....	....	10	....	....	....	
		30	5.25 a. m.	24.531	....	38½	34½	4	....	0	....	....	10	5,370	....	....	
Second camp near Fort Ellis		31	9.00 a. m.	25.118	....	71½	54½	17	W.S.W.	2	....	....	10	....	....	....	
		31	12.00 m	25.063	80½	80½	56	24½	W.S.W.	1	....	....	10	....	....	....	
		31	4.00 p. m.	24.977	81¼	80	54	26	W.N.W	2	Cir.-cu	....	9	....	....	....	
		31	7.30 p. m.	25.026	50½	49	43	6	....	0	....	....	10	....	....	....	
	Sept.	1	9.00 a. m.	25.141	71	72	53½	18½	....	0	....	....	10	....	....	....	Hazy.
		1	12.00 m	25.098	82½	78½	56	22½	S. W.	1	....	....	10	....	....	....	Do.
		1	5.00 p. m.	25.048	73½	72½	59	13½	....	0	Cir., cu.-str	....	1	....	....	....	
		1	7.00 p. m.	25.060	48½	48½	43½	5	....	0	Cir.-str., cu.	....	8	....	....	....	
		2	9.00 a. m.	25.120	69½	69½	53	16½	E.	1	Cir.-str., cu.	....	2	....	....	....	
		2	12.00 m	25.093	88½	88½	64½	24	E.	1	Cir.-cu	....	6	....	....	....	Hazy.
		2	3.30 p. m.	25.112	68	68½	51½	17	W.	3	Nim	....	0	....	....	....	Raining, wind changeable
		2	6.45 p. m.	25.077	56¾	56	49½	6½	N. E.	3	Cir.-cu., cir	W.	7	....	....	....	Rain from 3.30 till 5 p. m.
		3	9.00 a. m.	25.141	62	63½	53	10½	W.	2	....	....	10	....	....	....	Smoky.
		3	12.00 m	25.204	75½	75½	59	16½	W.	2	Cir.	....	4	....	....	....	Do.
		3	3.30 p. m.	25.176	77	77	59½	17½	W.	2	Cir., cir.-cu	W.	5	....	....	....	Do.
		3	6.30 p. m.	25.174	56½	56	50	6	E.	1	Cir.	....	9	....	....	....	Do.
		4	9.15 a. m.	25.140	65½	65	52½	12½	W.S.W.	1	....	....	10	....	....	....	Do.
		4	12.00 m	25.087	79½	78½	56½	22	W.S.W.	2	....	....	10	....	....	....	Do.
		4	3.30 p. m.	25.016	78½	80	56½	23½	W.N.W	2	....	....	10	....	....	....	Do.
		4	6.30 p. m.	25.036	57	55	45	10	E.	2	....	....	10	....	....	....	Do.
		5	6.45 a. m.	25.214	49	48½	41½	7	N. N. E.	2	....	....	10	4,789	....	....	Do.
Camp on small creek near Hamilton.		5	6.30 p. m.	25.632	59½	58½	51	7½	....	0	....	....	10	....	21.29	21.29	
		6	5.30 a. m.	25.682	32	32	28¾	3¼	....		Cir.-str	....	9	4,342	....	....	Smoky.
Allen's Ranch, Jefferson Valley.		6	3.00 p. m.	25.559	83½	81	60½	20½	....	0	Cir.-cu	....	4	....	20.35	41.64	
		6	6.30 p. m.	25.520	73½	73	52½	20½	W.S.W.	0	Cir.-str., cu.	....	1	....	....	....	
		7	5.30 a. m.	25.525	50	49½	40½	9	S. W.	2	Cir.-cu	S. W.	5	4,396	....	....	
South Bowlder Creek. 5 feet above the stream.		7	3.45 p. m.	25.193	75¾	75½	52½	23	N. W.	1	Cir.-cu., cu.-str	S. W.	5	....	22.46	64.10	Heavy clouds west, smoky.
										3							
		7	7.00 p. m.	25.253	67	66¾	47⅛	19¼	N. W.	1	Cir.-cu., cu.-str	S. W.	5	....	....	....	Drops of rain 6.15 p. m.
		8	5.30 a. m.	25.511	35	36	29	7	S.S.W.	2	....	....	10	4,565	....	....	Smoky.

Observations taken from Boteler's Ranch to Fort Bridger—Continued.

Camp of observation.	Date.	Hour of the day.	Barometric reading reduced to 32° F.	Detached thermometer.	Dry-bulb thermometer.	Wet-bulb thermometer.	Difference between wet and dry thermometer.	Direction of the wind.	Force of the wind.	Kind of clouds.	Direction of clouds.	Amount of clear sky.	Approximate elevation in feet.	Distance from camp to camp in miles.	Total distance from Fort Ellis in miles.	General remarks.
				°	°	°	°									
Fish Creek stage station	Sept. 8	3. 30 p. m.	25. 609	63½	63½	42½	21	N.N.W.	3			10		19. 10	83. 20	
	8	6. 30 p. m.	25. 679	49	47¾	34½	13¼	N.N.W.	1			10				
	9	6. 00 a. m.	25. 855	28¼	28¼	23½	4¾		0			10	4, 134			Smoky.
Beaver-Head Rock, near the stage station.	9	6. 30 p. m.	25. 396	59¾	58¼	42½	15¾	N.N. W	3			10		30. 89	114. 09	Very smoky.
	10	5. 35 a. m.	25. 488	28	28	21½	6½	S.	1			10	4, 464			
One mile from Beaver-Head River bridge at the cañon.	10	4. 30 p. m.	24. 974	70	68½	46½	22	N.N. W	1			10		21. 40	135. 49	
	10	6. 30 p. m.	24. 957	53¼	49¾	39¼	10½		0			10				
	11	6. 30 a. m.	24. 947	39¼	39	30¼	8¾	S. S. W.	5	Cir.		9	4, 988			
Horse Plain Creek	11	3. 00 p. m.	24. 713	72	72	49½	22½	N. E.	2			10		15. 61	151. 10	
	11	6. 30 p. m.	24. 715	63	62	42	20	N. E.	2	Cir.		9				
	12	6. 45 a. m.	24. 828	27¾	32	28	4	S. W.	1			10	5, 251			
Sage Creek, under Bald Mountain.	12	4. 20 p. m.	23. 767	68	68	45	23	E.	1	Cir.-cu., cir.-str.	S. W.	5		19. 74	170. 84	Smoky.
	12	6. 45 p. m.	23. 775	50	48	36	12		0	Cir.-cu., str.	S. W.	8				Do.
	13	6. 30 a. m.	23. 777	44½	44½	37½	7	S. W.	3	Cir., cir.-cu.		9	6, 252			Clouds, mostly west and north.
Camp on a branch of Red Rock Creek.	13	4. 45 p. m.	23. 416	70½	70	46½	23½	N. W.	3	Cir.-cu	N. W.	4		21. 95	192. 79	
	13	6. 45 p. m.	23. 418	42½	38½	28½	10	S. W.	2			10				
	14	6. 30 a. m.	23. 472	22	18½				0			10	6, 609			Thermometer 18° F. at sunrise.
First camp on Medicine Lodge Creek.	14	2. 40 p. m.	23. 891	74	72½	53¾	21¾	E. S. E.	3	Cir., cir.-str.		9		16. 05	208. 84	Very smoky.
	14	6. 30 p. m.	23. 881	57¾	57½	47	10½	N. W.	1	Cir.-cu., cir.-str.	N. W.	9				Clouds southeast.
	15	6. 00 a. m.	23. 908	37¾	37¾	30¼	7½		0	Cir., cir.-cu.		5	6, 110			Very smoky.
Second camp on Medicine Lodge Creek.	15	3. 45 p. m.	24. 826	73	73	55½	17½	N. E.	1	Cir., cir.-cu.		0		19. 95	228. 79	Do.
	15	6. 30 p. m.	24. 794	62	61	44½	16½	N. E.	1	Cir., cir.-str.	W.N.W	2				Do.
	16	6. 30 a. m.	24. 879	42	42	32½	9½	N. E.	1			10	5, 105			Do.
Desert Wells stage station, 6 feet above the mouth of the well.	16	4. 30 p. m.	25. 122	84½	84¼	57	27¼	W.S.W.	3			10		22. 65	251. 44	
	16	6. 20 p. m.	25. 090	70¼	70	50½	19½	S. W.	2	Cir.-cu	W.S.W.	5				
	17	5. 30 a. m.	25. 152	37½	37¼	27	10¼	S. E.	2	Cir.-str.		9	4, 816			
Camp on a bayou of Snake River, 3½ miles from Market Lake.	17	2. 00 p. m.	25. 174	82¼	82¼	57¼	25	S. W.	4	Cir., cir.-str.	S. W.	3		18. 94	270. 38	Smoke mostly blown away.
	17	6. 20 p. m.	25. 162	65	64½	47¼	17¼	S. W.	1	Cir.		8				
	18	6. 00 a. m.	25. 287	37¼	37¾	30¼	7½	N. E.	2	Cir.-cu		5	4, 790			
Camp at bridge over Blackfoot Fork of Snake River.	18	6. 15 p. m.	25. 425	68¾	68½	50	18½	S. E.	2	Cir.-str., cir.-cu.		9		33. 81	304. 19	
	19	5. 45 a. m.	25. 549	42	40½	35¼	5¼		0			10	4, 456			
Fort Hall, same spot as in June.	19	12 m.	25. 350	85	87½	59¾	27¾	N. E.	1	Cir.-cu., cu.	S. W.	9		7. 73	311. 92	Hottest at 2 p. m., 90° F.
	19	3. 45 p. m.	25. 301	83½	83	56¾	26¼		0	Cu.		9				

		19	6.00 p. m.	25.311	67	66½	47	19½	N. E.	1			10				
		20	9.00 a. m.	25.351	79	78	54	24	E. S. E.	2	Cir.		1				
		20	12 m.	25.316	87	87¾	56¾	31	S.S. W.	3	Cir., cir.-cu.	N. W.	9				Smoke southeast.
		20	3.15 p. m.	25.243	88	88	57	31	S. W.	3			10				
		20	6.30 p. m.	25.253	73½	72½	48	24½	S.	1			10				
		21	5.45 a. m.	25.218	65½	66½	46	20½	S. E.	1			10	4,720			
Camp on the head-waters of Port Neuf River, at the Chimney.		21	4.30 p. m.	24.527	77¾	78½	57	21½	W.S.W.	3	Cir.-cu	S. W.	9		18.70	330.62	Heavy wind 7 to 8 p. m.
		21	6.30 p. m.	24.528	64½	64½	46½	18	W.S.W.	4	Cir.-cu		9				
		22	5.30 a. m.	24.667	35½	35½	29½	6	E. S. E.	1			10	5,361			Do.
Twin Springs		22	3.00 p. m.	24.523	71	70½	48½	22	W.	2			10		22.65	353.27	
		22	6.20 p. m.	24.525	56½	57	39	18		0	Cir.-str.		9				
		23	5.45 a. m.	24.599	32	31½	26	5½		0			10	5,357			
Soda Springs, on the public square, 20 feet above Bear River.		23	11.00 a. m.	24.459	69½	70¼	52½	17¾	S. W.	2			10		10.34	363.61	
		23	1.30 p. m.	24.427	71½	71½	51	20½	S. W.	3			10				
		23	6.30 p. m.	24.434	55	53	42½	10½	S. E.	1			10				
		24	9.00 a. m.	24.474	67	67	69½	17½	E.	4	Cir., cir.-cu.		7				
		24	12 m.	24.423	77	78	54½	23½	S. E.	4	Cir.		7				
		24	3.20 p. m.	24.393	77¼	79	53½	25½	N. W.	2	Cir., cir.-str.		7				
		24	6.20 p. m.	24.400	55	55½	42	13½	E.	3	Cir.		9				
		25	5.30 a. m.	24.495	30½	32	26½	5½		0	Cir.-str.		8	5,529			
Bennington, public square		25	3.30 p. m.	24.183	74	74	52	22		0			10		26.45	390.06	Smoky.
		25	6.15 p. m.	24.180	62¾	63¼	44¾	18½		0	Cir.-str.		9				
		26	5.40 a. m.	24.227	38½	39	29½	9½	S. E.	1	Cir.-cu		9	5,798			
Camp north of Fish Haven, on Bear Lake Bottom.		26	3.30 p. m.	24.180	71¾	71¾	50¾	21	S. W.	1	Cir.-cu		9		26.98	417.04	
		26	6.20 p. m.	24.131	57½	57½	44¾	12¾	S. W.	1	Cir.-cu	S. W.	8				
		27	6.30 a. m.	24.065	54	55	47½	7½	N.	1	Cir.-cu	S.	8	5,911	23.92	440.96	
Camp on Sage Creek, 6 miles from Bear River.		27	6.15 p. m.	23.332	63½	62	43½	18½		0	Cir.-cu., cu.	S.	9	6,782	33.00	473.96	
Camp on Bear River		28	6.00 p. m.	23.482	61	60½	48	12½	S.	5	Nim.	S.	0	6,686	12.76	486.72	Storm of wind and rain.
Evanston, on the Union Pacific Railroad.		29	2.00 p. m.	23.312	45	45	41½	3½	S. S. E.	2	Cir., cu.-str.	S. S. E.	1				Do.
		29	4.00 p. m.	23.308	51¼	51¼	45½	5¾	S. S. E.	2	Cir., cu.-str.	S. S. E.	0				Do.
		29	6.15 p. m.	23.379	39	38½	35½	3	S. S. E.	2	Cir., cu.-str.	S. S. E.	0				
		30	9.15 a. m.	23.482	41	41	37	4	S. W.	3	Cir., cu.-str.	S. W.	0				
		30	12.45 p. m.	23.608	45	44½	37½	7	S. W.	4	Cir., cu.-str.	S. W.	0				
		30	3.15 p. m.	23.628	44¼	44¼	37½	7	S. W.	4	Cir., cu.-str.	S. W.	0				
		30	6.00 p. m.	23.680	42	42	37	5	S. W.	2	Cir., cu.-str.	S. W.	0				
	Oct.	1	6.30 a. m.	23.733	34	33½	30½	3	S. W.	3	Cir.-cu		4	*6,835			
Fort Bridger		2	8.30 a. m.	23.887	47	46½	39½	7	S.	3			10	†6,656	41.09	527.81	

* Union Pacific Railroad Survey.
† From data furnished by Charles A. Schott, United States Coast Survey.

RESULTS COMPILED FROM THE FOREGOING TABLES.

TEMPERATURE.—Temperature has been regarded in the work of observation, and a daily record kept. The greatest heat indicated was 97° Fah., August 17, 3.15 p. m., at Boteler's Ranch, Yellowstone Valley. The greatest cold, 14° Fah., August 10, sunrise, at Yellowstone Lake.

MOISTURE IN THE ATMOSPHERE.—The record of the wet and dry bulb thermometers furnishes many examples of large differences, indicating an extreme dryness of the air. The greatest difference was 37½°, (dry-bulb 97°, wet-bulb 59½°,) August 17, 3.15 p. m., at Boteler's Ranch, Yellowstone Valley; elevation, 4,925 feet.

RAIN.—The number of days during which rain fell was 30: in June, 7; in July, 11; in August, 9; in September, 2. Observations commencing June 10.

In the foregoing aggregate are included the thunder-storms accompanied by rain. The amount of rain which fell was slight in nearly every case. At Evanston we experienced a severe storm of wind and rain, which was attended by a curious rising of the barometer. In fact, so much was it affected as to be totally unreliable in its readings for elevation; consequently, it was set aside entirely, and the elevation determined by the Union Pacific Railroad Survey was adopted.

THUNDER-STORMS.—Five thunder-storms were experienced as follows: three in June; two in July. We recorded distant thunder, indicating a storm, upon seven other days; in June, 6; in August, 1.

SNOW.—Snow fell in small amount at Yellowstone Lake, August 12.

HAIL.—Hail was noted at Boteler's Ranch, August 6.

FROST.—A very heavy frost at Yellowstone Lake, August 13, was recorded.

AURORA BOREALIS.—Only one display of aurora borealis was noted, June 17 and 18, and this was not remarkable in its character.

Direction of wind for the month of June.

Direction whence	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Total.
Relative number of winds	7	6	1	8	8	10	5	7	52
Number of observations when there was no wind	......	......	......	......	......	......	......	......	16

Direction of wind for the month of July.

Direction whence	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Total.
Relative number of winds	8	8	11	2	10	18	13	10	80
Number of observations when there was no wind	......	......	......	......	......	......	......	......	7

Direction of wind for the month of August.

Direction whence	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Total.
Relative number of winds	9	12	8	3	8	19	10	5	74
Number of observations when there was no wind	......	......	......	......	......	......	......	......	4

Direction of wind for the month of September.

Direction whence	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Total.
Relative number of winds	4	5	9	6	6	11	7	4	52
Number of observations when there was no wind	......	......	......	......	......	......	......	......	18

Direction of wind during the Yellowstone Lake trip, from July 20 to August 27, inclusive.

Direction whence	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Total.
Relative number of winds	10	7	3	5	14	18	13	8	78
Number of observations when there was no wind	......	......	......	......	......	......	......	......	5

NOTE.—In the tables for the direction of the wind, the numbers represent the changes in direction. They are not the sums of the observations of each wind; as, where the same wind is noted several times in succession, it is regarded as one wind, and 1 represents it in the tables.

Relative force of wind for the month of June.

Direction whence	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Relative number of observations	9	8	1	11	10	11	7	11
Relative force of each wind	1.11	2.38	1.	1.91	1.9	1.3	1.9	2.5

Relative force of wind for the month of July.

Direction whence	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Relative number of observations	11	9	17	2	25	26	17	11
Relative force of each wind	1.82	1.44	2.06	1.	3.	2.42	1.76	1.45

Relative force of wind for the month of August.

Direction whence	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Relative number of observations	11	22	12	4	15	30	20	8
Relative force of each wind	1.36	2.14	1.92	1.50	2.53	2.93	2.50	1.75

Relative force of wind for the month of September.

Direction whence	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Relative number of observations	6	14	10	6	9	17	12	5
Relative force of each wind	1.83	1.55	1.90	1.83	2.55	2.24	2.33	2.

Relative force of wind during the Yellowstone Lake trip, July 20 to August 27, inclusive.

Direction whence	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Relative number of observations	11	11	3	8	24	23	19	9
Relative force of each wind	1.36	2.09	2.33	2.12	2.41	1.83	2.16	1.78

Movement of clouds during the month of June.

Direction whence	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Total.
Relative number of observations of direction	6	7	7	2	0	1	1	1	25
Clouds going in the direction of surface-current	1	2	0	0	0	1	0	0	4
Clouds going in direction opposite to surface-current	2	1	1	2	0	0	0	0	6

Movement of clouds during the month of July.

Direction whence	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Total.
Relative number of observations of direction	4	5	2	0	18	23	27	2	81
Clouds going in the direction of surface-current	1	1	0	0	6	7	8	0	23
Clouds going in direction opposite to surface-current	2	0	0	0	1	0	5	0	8

Movement of clouds during the month of August.

Direction whence	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Total.
Relative number of observations of direction	9	3	2	0	6	19	27	3	69
Clouds going in the direction of surface-current	0	2	1	0	4	5	7	0	19
Clouds going in direction opposite to surface-current	2	0	0	0	0	4	0	0	6

Movement of clouds during the month of September.

Direction whence	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Total.
Relative number of observations of direction	0	0	0	0	6	13	4	3	26
Clouds going in the direction of surface-current	0	0	0	0	4	7	1	2	14
Clouds going in direction opposite to surface-current	0	0	0	0	1	0	1	0	2

Movement of clouds during the Yellowstone Lake trip, from July 20 to August 27, inclusive.

Direction whence	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Total.
Relative number of observations of direction	2	3	4	4	4	8	9	1	35
Clouds going in the direction of surface-current	0	0	0	0	1	4	5	1	11
Clouds going in direction opposite to surface-current	0	1	1	0	0	0	0	0	2

In the column headed "Amount of clear sky," 0 indicates a sky entirely obscured by clouds; 10 indicates a sky entirely free from clouds, and intermediate numbers the relative proportion of clouds and clear sky.

We have the following averages: June, commencing on the 10th, 6.5; July, 5.7; August, 6.1; September, 7.1.

Days free from cloud: July 10, August 15 and 22, September 4, 5, 9, 10; day of total cloud, September 30.

Elevations of principal points.

	Feet.
Mt. Garfield, Idaho Territory, on the Atlantic and Pacific Divide	9,704
Bridger Mountain, Montana Territory, near Fort Ellis	8,355
Emigrant Peak, Montana Territory	10,629
Mount Washburn, Wyoming Territory	10,575
Mount Doane, east of Yellowstone Lake, Wyoming Territory	10,118
Yellowstone Lake, Wyoming Territory	7,427

Important divides on the line of travel, and their elevation.

	Feet
Divide between Box Elder Creek and Bear River	5,615
Divide between Bear and Port Neuf Rivers	5,042
Divide between Ross Fork of Snake River and Fort Hall	5,072
Divide between the Atlantic and Pacific Oceans, near Junction Station	6,430
Divide between Big Sage and Black-tailed Deer Creeks	7,044
Divide between Black-tailed Deer Creek and Stinking Water River	6,657
Divide between Stinking Water River and Alder Creek	6,492
Divide between Alder Creek and Madison River	6,857
Divide between Madison River and Hot Spring Creek	5,836
Divide between Hot Spring Creek and Madison River	5,079
Divide between Elk Creek and Gallatin River	4,641
Divide between Gallatin and Yellowstone Rivers	5,681
Divide between Sage and Red Rock Creeks	7,405
Divide between the Atlantic and Pacific Oceans, above Medicine Lodge Creek	7,255
Divide between Fort Hall and Port Neuf River	5,964
Divide between Bear Lake and Bear River	7,159
Divide between Yellowstone Lake and Madison River	7,911

The following list of points, with distances and elevations attached, has been made out from notes taken in the field by Mr. A. Schönborn and myself.

Here it may be well to state in brief a few of the main distances, as follows:

	Miles.
Ogden, Utah Territory, to Fort Hall, Idaho Territory	176.00
Fort Hall to Fort Ellis, Montana Territory	253.92
Fort Ellis to Yellowstone Lake, Wyoming Territory	118.80
Total distance from Ogden to Yellowstone Lake	548.72

	Miles.
Fort Ellis to Fort Hall, by way of Medicine Lodge Creek	311.92
Fort Hall to Evanston	174.80
Evanston to Fort Bridger, Wyoming Territory	41.09
Total distance from Fort Ellis to Fort Bridger	527.81

Table of distances and elevations.

Points.	Distance from point to point.	Total distance.	Elevation.
FROM OGDEN TO FORT ELLIS.	*Miles.*	*Miles.*	*Feet.*
Ogden, camp	0.00	....	4,517
Ogden City	1.71	1.71	*4,332
Water-tank, near Saline Springs	10.33	12.04	4,191
Willard City	4.07	16.11	4,350
Bottom of valley, south of Brigham City	5.31	21.42	4,345
Fork of road	.98	22.40	......
Second bridge over Box Elder River	2.52	24.92	4,762

* Union Pacific Railroad Survey.

Table of distances and elevations—Continued.

Points.	Distance from point to point.	Total distance.	Elevation.
FROM OGDEN TO FORT ELLIS—Continued.	*Miles.*	*Miles.*	*Feet.*
Copenhagen, camp	1. 85	26. 77	4, 999
Divide between Box Elder River and Bear River	4. 49	31. 26	5, 615
Lake, southwest corner	1. 99	33. 25	5, 378
Hill, top of, north of lake	. 70	33. 95	5, 491
Wellsville Camp	5. 71	39. 66	4, 568
Muddy Creek bridge, east of Wellsville	1. 90	41. 56	4, 508
Blacksmith's Creek bridge	5. 94	47. 50	......
Logan River bridge	1.	48. 50	4, 527
Logan, public square	. 83	49. 33	4, 557
Hyde Park	5. 17	54. 50	4, 553
Smithfield Creek, camp	2. 79	57. 29	4, 616
Hill, point north of Smithfield	1. 50	58. 79	4, 641
Richmond	4. 91	63. 70	4, 657
Creek, north of Richmond	2. 08	65. 78	4, 594
Franklin	4. 39	70. 17	4, 552
Cub River bridge	. 15	70. 32	4, 542
Point near Prairie Hill	1. 21	71. 53	4, 573
Grass Creek, camp	3. 19	74. 72	4, 624
Edge of first terrace, east of Bear River	4. 22	78. 94	4, 738
Bear River bridge	1. 66	80. 60	4, 543
Clifton	6. 45	87. 05	4, 893
Oxford	5. 82	92. 87	4, 862
Divide between Bear River and Port Neuf River	1. 42	94. 29	5, 042
Grasshopper Creek, camp	1. 78	96. 07	4, 706
Red Rock Ranch	4. 93	101. 00	4, 711
Station on edge of terrace, east of Marsh Creek	5. 79	106. 79	4, 856
Nine-Mile Ranch	2. 89	109. 68	......
Marsh Creek, camp	7. 80	117. 48	4, 626
Watson's Ranch	1. 81	119. 29	......
Port Neuf River bridge	6. 53	125. 82	......
Port Neuf River, camp	5. 82	131. 64	4, 565
Large fork of Port Neuf River	4. 14	135. 78	......
Port Neuf River, second camp	12. 20	147. 98	4, 441
Ross Fork bridge	12. 62	160. 60	......
Ross Fork, camp	. 72	161. 32	4, 394
High prairie terrace	1. 05	162. 37	4, 632
Fork of road, leave Ross Fork	2. 17	164. 54	4, 539
Divide between Ross Fork and Blackfoot Fork	6. 93	171. 47	5, 072
Fort Hall, camp	4. 53	176. 00	4, 720
Blackfoot Fork bridge, camp	7. 20	183. 20	4, 456
Point opposite high plateau	6. 16	189. 36	4, 440
Snake River, Taylor's bridge	13. 25	202. 61	......
Snake River, camp	. 43	203. 05	4, 627
Eagle Rock	8. 18	211. 23	......
Bayou from Snake River	8. 42	219. 65	......
Market Lake, camp	3. 44	223. 09	4, 795
Desert Wells	12. 89	235. 98	4, 816
Camas Creek, camp	4. 82	240. 80	4, 687
Camas Creek, ranch	5. 32	246. 12	4, 722
Dry Creek, camp	13. 09	259. 21	5, 031
Little Creek	4. 75	263. 96	5, 355
Dry Creek, stage station	4. 19	468. 15	5, 689
Hill, top of, south of Pleasant Valley	7. 12	275. 27	6, 206
Pleasant Valley, camp	. 59	275. 86	6, 086
Hill, top of, north of Pleasant Valley	. 78	276. 64	6, 236
High ridge	3. 31	279. 95	6, 508
Divide between the Atlantic and Pacific Oceans	5. 89	285. 84	6, 480
Junction, stage station, camp	7. 77	293. 61	6, 329
Divide between Willow Creek and Red Rock Creek	2. 47	296. 08	6, 268
Red Rock Creek, first ford	2. 25	298. 33	6, 041
Red Rock Creek, second ford	. 83	299. 16	6, 041
Divide between Red Rock Creek and Big Sage Creek	3. 79	302. 95	6, 307
Terrace south of Big Sage Creek	2. 19	305. 14	6, 002
Little Sage Creek, ford	4. 74	309. 88	5, 924
Divide between Big Sage Creek and Black-tailed Deer Creek	6. 11	315. 99	7, 044
Wild-Cat Creek, camp	. 58	316. 57	6, 988
Black-tailed Deer Creek, camp	6. 82	323. 39	5, 973
Divide between Black-tailed Deer Creek and Stinkingwater River	6. 40	329. 79	6, 657
Mouth of Sweetwater Cañon	4. 53	334. 32	5, 872
End of Sweetwater Cañon	1. 35	335. 67	5, 607
Stinkingwater River, camp	6. 16	341. 83	5, 437
Point opposite high terrace	3. 26	344. 09	5, 307
Terrace above and north of creek	. 21	345. 30	5, 382
Stinkingwater Valley, point of departure	7. 19	352. 49	5, 602
Terrace	2. 21	354. 70	5, 937

Table of distances and elevations—Continued.

Points.	Distance from point to point.	Total distance.	Elevation.
FROM OGDEN TO FORT ELLIS—Continued.	*Miles.*	*Miles.*	*Feet.*
Divide between Stinkingwater River and Alder Creek	1.31	356.01	6,492
Nevada City	2.54	358.55	5,548
Virginia City	1.44	359.99	5,713
Springs northeast of Virginia City, camp	1.19	361.18	5,961
Divide between Madison River and Jefferson River	2.97	364.15	6,857
Madison River, camp	7.57	371.72	5,177
Meadow Creek, ford	8.99	380.71	5,086
Divide between Meadow Creek and Hot Spring Creek	3.73	384.44	5,836
Hot Spring Creek, camp	2.98	387.42	4,804
Divide between Hot Spring Creek and Madison River	6.10	393.52	5,079
Madison River bridge	3.67	397.19	4,342
Cherry Creek ford	1.68	398.87	......
Prairie Hill	4.27	403.14	4,606
Elk Creek, camp	3.03	406.17	4,438
Divide between Madison River and Gallatin River	5.24	411.41	4,834
West Gallatin River bridge	6.20	417.61	4,618
Middle Gallatin River	1.85	419.46	4,587
Boseman	6.39	425.85	4,655
Fort Ellis, camp	4.07	429.92	4,789
FORT ELLIS TO FORT BRIDGER.			
Fort Ellis, camp	0.00	....	4,789
Boseman	4.23	....	4,655
West Gallatin River	9.85	14.08	......
West Gallatin River, ford	4.76	18.84	......
Spring Creek, near Hamilton, camp	2.45	21.29	4,342
Hamilton	.92	22.21	4,357
Gallatin River, narrows	7.25	29.46	4,210
Gallatin River, end of narrows	1.30	30.76	......
Madison River, north fork	2.57	33.33	4,210
Madison River, south fork	.92	34.25	......
Allen's Ranch, camp	7.39	41.64	4,396
Willow Creek, ford	1.91	43.55	4,401
Willow Creek, point of departure	1.62	45.17	4,534
High hill	4.49	49.66	5,337
Valley of Willow Creek	3.42	53.08	......
Small Creek, from left	2.24	55.32	......
Divide between Willow Creek and South Boulder River	5.43	60.75	4,948
Creek	1.94	62.69	......
South Boulder River, ford	.71	63.40	......
South Boulder River, camp	.70	64.10	4,565
Hill	.90	65.00	4,565
Jefferson River, east fork, ford	2.23	67.23	......
Jefferson River, west fork, ford	5.00	72.23	......
White-tailed Deer Creek	2.08	74.31	......
Pipe-Stone Creek	1.03	75.34	......
Creek	2.96	78.30	......
Fish Creek, stage station, camp	4.90	83.20	4,134
Jefferson River, Parson's bridge	1.25	84.45	4,083
Jefferson River, bend	3.25	87.70	......
Beaverhead River, first bridge	13.20	100.90	4,228
Beaverhead Rock, second bridge over Beaverhead River	12.83	113.73	......
Beaverhead Rock, stage station, camp	.36	114.09	4,464
Carter's Creek	8.76	122.85	......
Mail station	1.94	124.79	......
Black-tailed Deer Creek	5.45	130.24	4,879
Beaverhead River, one mile from cañon, camp	5.25	135.49	4,988
Hill, top of	4.87	140.36	5,147
Top of terrace at the junction of Beaverhead River and Horse Plain Creek	8.14	148.50	5,206
Beaverhead River ford, point of departure	.90	149.40	5,130
Hill, top of	.53	149.93	5,251
Horse Plain Creek	1.17	151.10	5,251
Sage Creek, camp	19.74	170.84	6,252
Sage Creek, ford	2.92	173.76	6,640
Small Creek	3.07	176.83	......
Hill, top of	.65	177.48	6,785
Creeks, at junction	.42	177.90	......
Creek from right	1.78	179.68	6,980
Divide between Horse Plain Creek and Red Rock Creek	2.77	182.45	7,405
Branch of Red Rock Creek	1.36	183.81	6,976
Branch of Red Rock Creek, point of departure	3.17	186.98	6,799
Hill, top of	4.71	191.69	6,799
Second branch of Red Rock Creek	.99	192.68	6,598
Small branch of Red Rock Creek, camp	.11	192.79	6,609
Small branch of Red Rock Creek	2.87	195.66	6,631

Table of distances and elevations—Continued.

Points.	Distance from point to point.	Total distance.	Elevation.
FORT ELLIS TO FORT BRIDGER—Continued.	*Miles.*	*Miles.*	*Feet.*
Divide between the Atlantic and Pacific Oceans	2.58	198.24	7,255
Medicine Lodge Creek	2.20	200.44	6,420
Junction of two branches of Medicine Lodge Creek	4.98	205.42	......
Medicine Lodge Creek, camp	3.42	208.84	6,110
High basalt plateau, point of departure, Medicine Lodge Creek	10.99	219.83	6,565
Medicine Lodge Creek, second camp	8.96	228.79	5,105
Medicine Lodge Creek ford, point of departure	1.98	230.77	......
Dry Creek	8.24	239.01	......
Camas Creek	7.12	246.13	4,687
Desert Wells, camp	5.31	251.44	4,816
Bayou of Snake River, camp	18.94	270.38	4,790
Snake River, Taylor's bridge	......	......	4,627
Blackfoot Fork, near the bridge, camp	33.81	304.19	4,456
Fort Hall, camp	7.73	311.92	4,720
Divide between Blackfoot Fork and Port Neuf River	8.60	320.52	5,964
Branch of Port Neuf River, ford	9.62	330.14	......
Branch of Port Neuf River, camp	.48	330.62	5,361
Branch of Port Neuf River, point of departure	7.03	337.65	5,217
Large branch of Port Neuf River	5.47	343.12	5,286
Twin Springs, camp	10 15	353.27	5,357
Cross roads, Bear River Valley	5.65	358.92	5,315
Hill west of Soda Springs	3.50	362.42	5,482
Soda Spring Creek	1.03	363.45	......
Soda Springs, west village, camp	.16	363.61	5,529
Pyramid Spring	.93	364.54	5,614
Saint George	18.08	382.62	5,771
Bennington, camp	7.44	390.06	5,798
Montpelier	4.02	394.08	5,793
Bear River bridge	2.57	396.65	5,744
Creek	1.19	397.84	5,744
Creek	2.10	399.94	......
Ovid	.07	400.01	5,760
Paris	4.39	404.40	5,836
Paris Creek, ford	.32	404.72	......
Bloomington	2.40	407.12	5,9[illegible]5
Saint Charles	5.09	412.21	5,932
Fish Haven, camp, Bear Lake	4.83	417.04	5,911
Fish Haven	.35	417.39	5,932
Idaho, south boundary line stone	2.88	420.27	......
Swan Creek	1.52	421.79	5,922
Bear Lake, point of departure	10.15	431.94	5,931
Lake Town	2.10	433.04	6,001
Divide between Bear Lake and Bear River	4.39	437.43	7,159
Sage Creek, camp	2.53	440.96	6,782
Bear River Valley, point of entrance	5.31	446.27	6,361
Randolph	7.83	454.10	6,442
Woodruff, point opposite	9.82	463.92	......
Hill in the bend of Bear River	8.97	472.89	6,832
Bear River, camp	1.07	473.96	6,686
Bear River, ford	8.65	482.61	......
Bear River bridge	3.08	485.69	......
Evanston, camp	1.03	486.72	6,835
Bear River, ford	9.06	495.78	7,078
Sulphur Creek	.96	496.74	......
Sulphur Creek, ford, Bad Town	.84	497.58	7,151
Quaking Asp, divide	5.79	503.37	7,689
Muddy Creek	11.94	515.31	6,948
Fort Bridger	12.50	527.81	6,656

EXPLANATION OF THE PLATES OF ORTHOPTERA.*

Plate I.

Fig. 1. *Anabrus simplex,* Hald.
2. *Œdipoda tenebrosa,* Scudd.
3. *Brachypeplus virescens,* Charp.
4. *Caloptenus differentialis,* Thos.
5. *Gryllus formosus,* Say.
6. *Œdipoda trifasciata,* Say.

Fig. 7. *Acrolophitus hirtipes,* Thos.
8. *Decticus pallidipalpus,* Thos.
9. *Locusta fuliginosa,* Thos.
10. *Gryllus luctuosus,* Serv.
11. *Gryllus luctuosus,* Serv.

Plate II.

Fig. 1. *Acridium frontalis,* Thos.
2. *Caloptenus occidentalis,* Thos.
3. *Caloptenus viridis,* Thos.
4. *Caloptenus Dodgei,* (male,) Thos.
5. *Caloptenus Dodgei,* (male.)
6. *Caloptenus differentialis,* var. *a,* Thos.
7. *Opomola bivittata,* Serv.
8. *Opomola Wyomingensis,* Thos.
9. *Caloptenus Dodgei,* (female,) Thos.

Fig. 10. *Caloptenus Turnbullii,* Thos.
11. *Ephippitytha gracilipes,* Thos.
12. *Phaneroptera Coloradensis,* Thos., (MS.)
13. *Pezotettix obesa,* Thos.
14. *Pezotettix obesa.*
15. *Ephippigera tschivavensis,* Hald.
16. *Locusta occidentalis,* Thos.
17. *Pterolepis minutus,* Thos.

* These two plates of Orthoptera, are copied by permission of Professor T. Glover, from IX and XI of his admirable plates of American Orthoptera, and although containing none but western species, have two or three species to which I do not refer.

GEOLOGICAL SURVEY OF THE TERRITORIES.

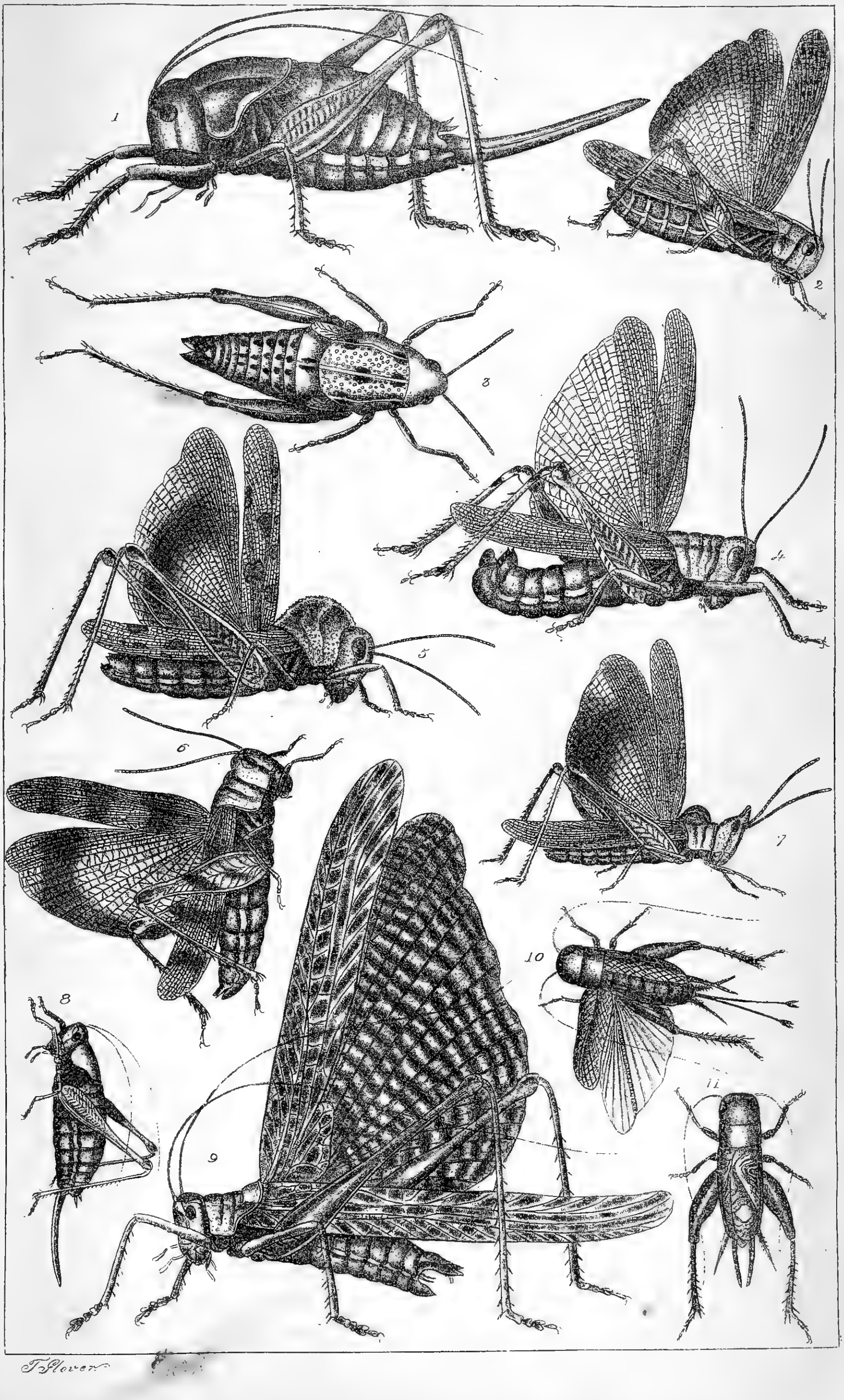
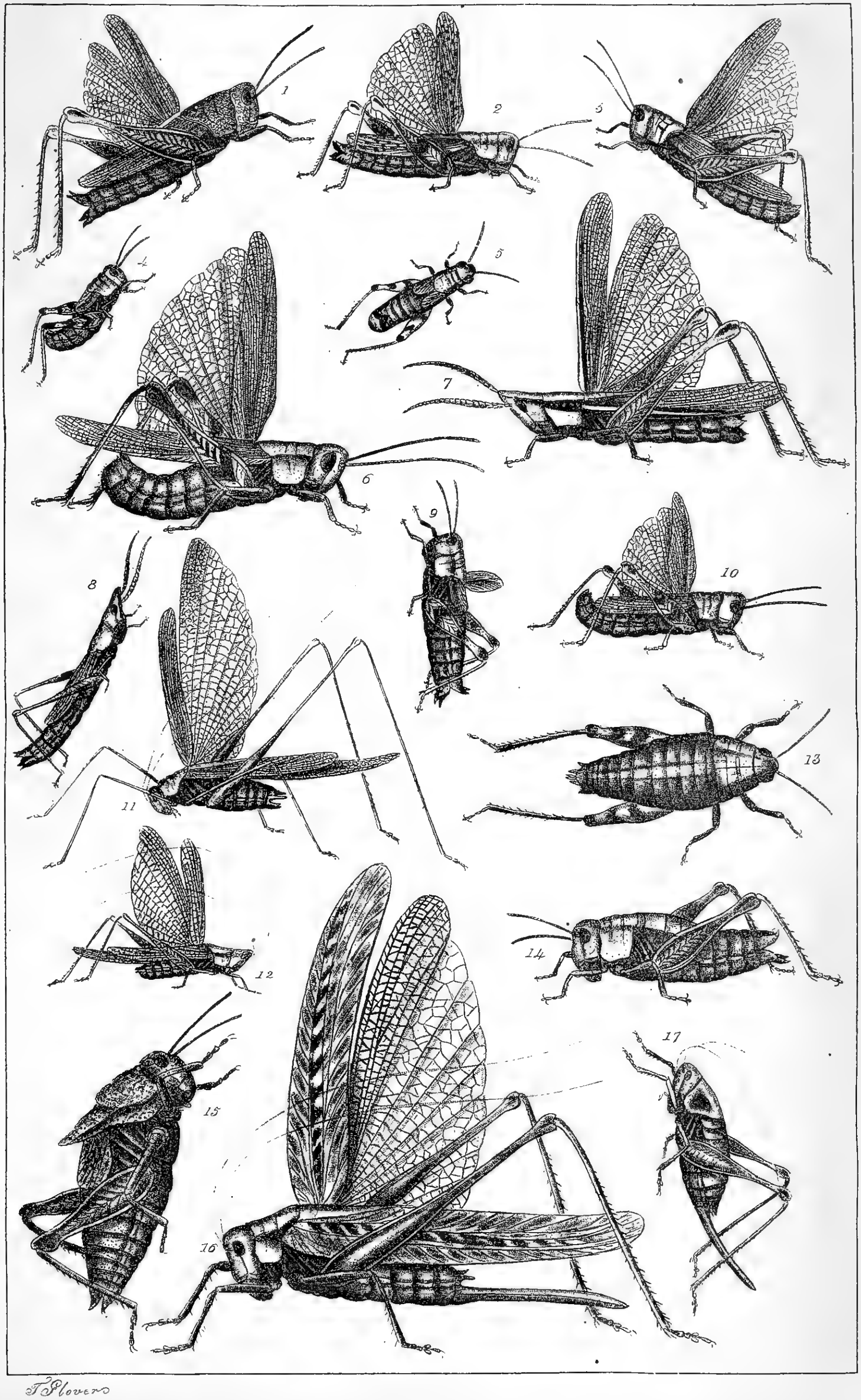


PLATE II.

GEOLOGICAL SURVEY OF THE TERRITORIES.



T. Glover

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SUPPLEMENT TO THE FIFTH ANNUAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY

OF

THE TERRITORIES FOR 1871.

F. V. HAYDEN,

UNITED STATES GEOLOGIST IN CHARGE.

REPORT ON FOSSIL FLORA.—BY LEO LESQUEREUX.

CONDUCTED UNDER AUTHORITY OF THE SECRETARY OF THE INTERIOR.

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1872.

PREFATORY NOTE.

'he materials composing the following report were not accessi- at the time my annual report was printed, and are now issued in form of a supplement. Full descriptions and illustrations of the v and little known species will appear in the final reports, now in an 'anced state of preparation.

F. V. HAYDEN,

United States Geologist in charge.

'FFICE U. S. GEOLOGICAL SURVEY OF THE TERRITORIES,

Washington, May 13, 1872.

AN ENUMERATION WITH DESCRIPTIONS OF SOME TERTIARY FOSSIL PLANTS, FROM SPECIMENS PROCURED IN THE EXPLORATIONS OF DR. F. V. HAYDEN, IN 1870.

BY LEO LESQUEREUX.

This enumeration may be considered as an appendix to the paper on the same subject, in the last report of Dr. F. V. Hayden. This report was just delivered and already in the hands of the printer when the materials on which the present notes are written were received. The specimens would have been reserved for a later examination, with that of others which may be procured this year. But as some of them give evidence of the age of formations at some localities which in the report are marked as unknown; as others represent new and remarkable forms; and others still have better preserved remains of species indifferently known as yet, it was advisable to examine them at once and to prepare and publish a short account of them.

In this paper the same plan is followed as in Dr. Hayden's report: 1st, description of species, grouped according to the localities where they have been found; 2d, some remarks on the analogy of these species, in relation to their geographical and stratigraphical distribution and to their typical characters, &c.

1. GREEN RIVER, ABOVE FISH-BEDS.

Fine-grained, buff-colored, hard shale, breaking more or less irregularly in horizontal layers.

HEMITELITES TORELLI, Heer (?). Represented by a very small fragment, only a single oblong leaflet, entire or slightly undulate on the borders, with nervation of this species as figured in Fl. Arc., 2, Pl. xl, Fig. 1–5. Identity cannot be positively ascertained from such a specimen.

ARUNDO GÖPPERTI, Munst. To this species I refer an irregularly, narrowly, striate stem with round knots, as in Fl. Ter. Helv., Pl. xxiii, Fig. 11. The same specimen bears a crushed fascicle of seeds of an *Arundo* (?). Other specimens still doubtfully referred to this species represent roots or root-stocks, varying from $\frac{1}{4}$ of an inch to $1\frac{1}{2}$ inches in diameter, irregularly, more or less striate-wrinkled in the length, marked also, as in the first specimens, by round knots, placed at a distance from each other and without trace of articulations. These remains may belong as well to a *Phragmites* as to an *Arundo*. The comparison of the seeds may indicate their true relation.

PHRAGMITES OENINGENSIS, Al. Br. Fragments of doubly striated stems, marked by articulations as in Report, p. 284.*

JUNCUS, *species*. Fragments of stems of various size, like *Juncus retractus*, Heer, or *Juncus Scheuzeri*, Heer, in Fl. Ter. Helv., Pl. xxx, Figs. 2 *e* and 3 *c*.

* Quotations marked Report refer to my former paper in Dr. F. V. Hayden's last report, 1872.

Salix angusta, Al. Br., in Heer's Fl. Ter. Helv., 2, p. 30, Pl. lxix, Fig. 3. One of the specimens represents a whole leaf 6 inches long 13 to 14 millimeters broad, in its widest part entire, linear, gradually tapering to a long point, and tapering also by a slightly curved line to the petiole. This leaf shows apparently its upper surface. The medial nerve is broadly marked, but the secondary veins are obsolete like their divisions. Another specimen of the same species has only one-half of a leaf of about the same width as the former, the under part, with secondary veins, very distinct, like their divisions, and surface evidently villose, it being marked by the impression of a thick coat of hairs. Heer, in his description of this species, rightlyc ompares it to *S. viminalis*, L., remarking, however, that his specimens do not indicate if the leaves were villose as in the living species.

Salix media, Al. Br. For the form of the linear lanceolate leaves with entire borders, tapering upward to a point, obtuse at base, our specimens represent exactly this species as figured in Fl. Ter. Helv., Pl. lxviii, Figs. 14, 17, 19. But they do not show any trace of nervation, and identity is, therefore, uncertain. It is, however, generally the case in specimens of this species whose upper surface is smooth and do not bear any trace of secondary veins.

Salix, *species*. Merely the base of two leaves still attached to a branchlet, alternate, with unequal base, just as in *S. inæquilatera*, Göpp., Schossnitz Fl., Pl. xxi, Fig. 6; very short-petioled, nearly sessile, with entire or undulately crenulate borders; apparently narrowly lanceolate-pointed; secondary veins open, thick like the intermediate shorter tertiary veins and nervilles; areolation distinct, of the same type as that of *S. Lavateri*, Heer. As much as can be seen, these leaves do not resemble any fossil species as yet published; but as the form of the leaves is not known, and as it is not seen if the borders are entire or denticulate, it is useless to attempt specification.

Myrica nigricans, *sp. nov.* Fragments of leaves, apparently narrowly lanceolate or linear-lanceolate, half an inch wide or less, passing down in an outward curve and cuneate to the petiole, distantly serrate, with short obtuse teeth; medial nerve thick, secondary veins open, (angle of divergence at least 60°,) distinct, branching downward two or three times in anastomosing with intermediate short tertiary veinlets. The nervation is analogous to that of the living *M. gale*, L., while by the form of the leaves it resembles *M. Vindobonensis*, Ung., as figured by Heer in Alaska Fl., Pl. iii, Fig. 5, differing, however, by the distant obtuse teeth of the borders. All the specimens of these leaves are blackened upon the yellow shale of this locality, and the surface appears dotted, as in our common *M. cerifera*, L., indicating a resinous compound in their texture. Some of the specimens bear small round seeds, which may be referred to this species.

Myrica salicina, Ung. As far as identity can be ascertained from the outline of the leaves and with undistinct nervation, the leaf or part of leaf of the specimen (the point and base being destroyed) is the same as the one figured in Fl. Ter. Helv., Pl. lxxi, Fig. 2. The thin secondary veins, a few of which are discernible, have the same direction as in the European form and branch near the point as in species of this genus.

Quercus lonchitis, Ung. A small specimen, a narrow, lanecolate leaf, with serrate borders and secondary veins numerous, parallel, simple, craspedodrome, is referable to this species as figured in Fl. Ter. Helv., Pl. cli, Figs. 22 and 23.

Ficus populina, Heer. A number of specimens agree with the forms of this species as described and figured in Heer, Fl. Ter. Helv., from

European specimens, presenting, however, some marked differences. The leaves are not long-acutely pointed, but obtusely so; though the primary and secondary nervation are alike, the ultimate divisions of the veins approach nearer to the borders, and sometimes the teeth of the borders appear rather pointed than round. As this species is very variable, these differences are not marked enough to authorize a separation. The general form of these leaves of ours rather resembles the variety in Heer's Fl. Ter. Helv., Pl. lxxxv, Figs. 1 and 2.

FICUS UNGERI, *sp. nov.* A splendid leaf, of which unluckily the point and lower part are destroyed. It is broadly lanceolate in outline, the borders nearly parallel in the middle of the leaf, apparently rounded to the petiole and also curving upward somewhat abruptly to a point. The part of the leaf as it is preserved is 8 inches long, 4 inches wide, with entire, slightly undulate borders, not coriaceous; medial nerve rather thick; secondary veins at a broad angle of divergence, (70° to 80°,) and tertiary nervation distinct, of the same type as that of *F. Americana.* The surface of the leaf is runcinate, as in *F. populina* and *F. tiliæfolia;* but the form of the leaf and the open, nearly horizontal secondary veins separate this species from any other known as yet in a fossil state. The leaf is larger than that of *F. Hercules*, Ett., or that of *F. Ruminiana*, Heer; comparable only, for the form and size, to the living *F. ferruginea*, which has also the secondary veins in an open angle. In the fossil species, these veins curve less abruptly and approach nearer to the borders in their ultimate curve.

CINNAMOMUM SCHEUZERI, Heer. I refer to this species two leaves of *Cinnamomum*, one of which is contracted above the base, as in some forms of *C. Buchi*, Heer; the other narrower, like a variety of *C. lanceolatum*, Heer. Both specimens are incomplete and have the nervation of *C. Scheuzeri*, as represented in many specimens from other localities of our Tertiary.

EUCALYPTUS AMERICANUS, *sp. nov.* Represented by good specimens. Leaves narrowly lanceolate, 5 to 6 inches long, $\frac{1}{2}$ to $\frac{3}{4}$ of an inch wide, entire, gradually tapering upward to a long point, tapering also, but less gradually, to the base of the flat, broad, medial nerve, which is merely enlarged at the point of attachment; secondary veins oblique, (divergence about 30°,) numerous, ascending nearly straight to near the borders, where they join a marginal vein, which follow the borders from the base to the point of the leaves, being scarcely bent to the point of union of the secondary veins, and thus forming a narrow, equal margin, marked by horizontal, thin, simple, parallel, and close veinlets. This fine species is distantly related to *E. Oceanica*, Heer, Fl. Ter. Helv., and may be still more so to *E. rhododendrifolia*, of Massalonga, which has, like ours, the true nervation of *Eucalyptus*, but is differing at least by its leathery texture, which is no coriaceous in ours. I know this Italian species merely from description, and cannot, therefore, indicate points of analogy.

AMPELOPSIS TERTIARIA, *sp. nov.* A digitate leaf, with five narrowly ovate, lanceolate-pointed leaflets, tapering downward to a short, slightly winged petiole, sharply serrate on the borders; medial nerve flat and broad; secondary veins in acute angle, curving along the borders, branching upward and anastomosing downward with branches of the upper veinlets. The nervation is similar to that of our living *A. quinquefolia*, Michx., the branches of the secondary veins entering the teeth, while the primary divisions follow the borders. It differs from it, however, by smaller and narrower leaves, short, winged petiole, &c.

The upper part of the leaflets is narrowed into a point, and the borders are serrate to the point.

ILEX AFFINIS, *sp. nov.* Leaf coriaceous, broadly ovate, round cuneate to the base, (point destroyed,) with borders narrowly margined, distantly dentate. Secondary veins open, nearly perpendicular to the medial nerve, curving near the borders, thin though distinct. Areolation and tertiary nervation like that of *I. coriacea*, Chap., of Florida. The fossil leaf differs from the living species by thinner, more open secondary veins, curving more gradually toward the borders, and by the teeth, rather turned upward, and not spiny. The spines, however, may have been destroyed by maceration. These differences are of not much account, and both species are closely related, if not identical.

ILEX STENOPHYLLA, Ung. The specimens represent the form figured by Heer, Fl. Ter. Helv., Pl. cxxii, Fig. 7. Leaf coriaceous, narrowly ovate, lanceolate, obtusely pointed, with entire borders; medial nerve strong; secondary veins thin, the inferior ones more oblique; areolation same as in Heer's Fig. 7. All the specimens of this species represent large leaves, none of them as small as those figured by Unger in the Chloris, and by Heer, *loc. cit.*, Figs. 8 and 8b. Except this, no point of difference is remarked.

CEANOTHUS CINNAMOMOIDES, Lsqx. Same form as described in Report, p. 289. The teeth are more sharply marked than in the first specimens examined.

RHUS ACUMINATA, *sp. nov.* A single leaf, ovate in outline, narrowed by an inward curve to a short, flat petiole, abruptly acuminate, with borders irregularly crenulate-lobed. Secondary veins open, strong, branching near the point, mostly craspedodrome in the lower part of the leaf, while in the upper part some abruptly curve near the borders and run along them. By its nervation, the species is like *R. Pyrrhæ*, Ung., except that the secondary veins are more numerous, in our specimen nearly as close to each other as in *R. Meriani*, Heer. It is distantly related to our living *R. aromatica*, Ait.

JUGLANS SCHIMPERI, *sp. nov.* A very fine species, represented by a number of specimens, all with the same characters. Leaves of a somewhat thick, but not coriaceous texture, lancealate in outline, entire, largest near the base, about 1½ inches broad, hence gradually tapering upward into a long acute point, abruptly rounded downward to the petiole; whole length of the leaves about 6 inches; from the broadest part to the point 4½ inches. It is comparable to some forms of *J. rugosa*, Lsqx., but the form of the leaves, gradually decreasing to a point, is different, as also the nervation, which, like the areolation, is more distinct. The medial nerve is flat or grooved; the secondary veins more oblique, (angle of divergence, 42° to 45°,) more numerous and close to each other, 16 to 18 pairs in each leaf, curving slightly in ascending, and still more in coming to the borders, which they closely follow in their ultimate divisions.

JUGLANS ACUMINATA, Heer (?). The same leaf, in all its characters, as the one figured in Fl. Ter. Helv., Pl. cxxix, Fig. 6, and which is apparently far different from any other form of this species. Professor Heer, in his description, has no remarks about this peculiar form: rather comparable to *J. costata*, Ung., as figured by Ludwig in Pal., Vol. VIII, Pl. lvii, Fig. 7, and Pl. lvi, Fig. 7. In all the specimens of this locality, there is no leaf referable to *J. acuminata*, Heer, or to its relative, *J. rugosa*, Lsqx.

JUGLANS DENTICULATA, Heer, (?) Fl. Arc., 2, p. 483, Pl. lvi, Figs. 6–9. In describing this species, the author remarks that it is like *J. Bilinica*, Ung., with more delicate teeth and secondary veins curving nearer

to the borders. The leaves, which I think referable to this species, are like Fig. 9, *loc. cit.*, obovate, gradually narrowed downward to the petiole and more abruptly pointed. Near the base, the borders are nearly entire or slightly serrulate, as in the leaves figured by Heer, *loc. cit.;* but from below the middle upward, they are coarsely and sharply serrate. The secondary veins are equidistant, parallel, gradually curving from the medial nerve to near the borders, where the curve becomes more marked, following the borders and sending strong branches to the point of the teeth. The nervation of this species is well marked and similar to that of some of our living species of *Juglans: J. rupestris*, Engl., for example, from California. One of the specimens bears three leaflets still apparently attached to a common petiole, and all have the same form, same size and nervation. In all our specimens the secondary veins are more curved than in any of the figures given by Heer. It is with this species as with *J. rugosa* compared to *J. acuminata;* identity is not more recognizable than characters to point out specific differences.

2. Point of Rocks Station, Union Pacific Railroad.

Fine-grained, brown, ferruginous, very hard shale, with generally broken remains of leaves flattened in the plane of stratification.

Onoclea sensibilis, L., as described by Dr. Newberry in Notes on The Later Extinct Floras, &c., p. 39, and figured, Pl. viii, ined. The specimen is upon a piece of white, hard limestone from near the mouth of the Yellowstone River.

Populus arctica, Heer. Same form as that of Fl. Arc., Pl. v, Fig. 9. The leaf is broken and its outline obsolete.

Quercus Olafseni, Heer (?). The specimen only shows the middle part of a leaf oval in outline, at least six inches long, four inches wide, with secondary veins oblique, parallel, straight, as represented for this species and for *Q. Grœnlandica*, Heer, in Fl. Arc., Pl. x, Figs. 3 and 5.

Corylus McQuarrii, Forb. In many specimens, representing it in various forms of its leaves.

Corylus grandifolia, Newy. It may be a variety of the former species, of which so many are described and figured by Heer in the Arctic Flora. The essential difference is not in the size of the leaves, but in the greater distance between the secondary veins, especially the two lower pairs. The nearest form to this one is that in Heer's Fl. Arc., Pl. ix, Fig. 3.

Platanus Guillelmæ, Heer, (?) apparently. The characters of the leaf are scarcely distinguishable.

Andromeda, *species*. Two specimens representing the same part of a leaf: its lower part with the petiole. Its form is intermediate between that of *A. Grayana*, Heer, and *Diospiros lancifolia*, Lx.; ovate-lanceolate, one inch wide in the middle, where it is broken, gradually tapering to the petiole by an inward curved line; petiole one-half inch long, narrow, like the medial nerve; one pair only of secondary veins are discernible, ascending from the base of the leaves and following the borders. The other veins above are undistinctly seen, emerging in a more open angle, and curving to the borders.

Cornus rhamnifolia, Heer, Fl. Ter. Helv., p. 28, Pl. cv, Figs. 22–25. It resembles somewhat *Juglans rugosa*, Lx., in some of its varieties, differing by shorter and broader leaves, two inches wide, scarcely two and a half inches long; secondary veins all simple, nearly straight, slightly diverging from each other in passing from the medial nerve to quite near the borders, where they curve abruptly; nervilles distinct,

perpendicular to the veins, which preserve the same thickness in their whole length. Identical in characters with the European species.

Vitis Islandica, (?) Heer, Fl. Arc., Pl. xxvi, Figs. 1 and 7*a*. Three broken undistinct specimens of lobate leaves, whose nervation is like that of Fig. 7*c*, *loc. cit.*, are doubtfully referred to this species, most of the outlines of the leaves being destroyed. They might be referable to *V. Olriki*, Heer, which has been obtained in better specimens at Evanston.

DOMBEYOPSIS ÆQUIFOLIA, Göpp., Fl. Ter. Schles., p. 22, Pl. iv, Fig. 4, and Pl. v, Fig. 2*a*. The leaf representing this species is only smaller than those figured by Göppert, *loc. cit.* The form, however, and the nervation are alike. It is broadly cordate, equal, entire on the borders, with 5 to 7 primary veins from the base; medial vein branching at a distance above the base; upper basilar veins much divided outside; fibrilles thick, parallel. The specimen shows only the lower half of one leaf.

JUGLANS RUGOSA, Lsqx. My remarks on *J. rhamnoides*, in Report, p. 294, apply to some forms of this species as represented by the numerous specimens of this locality. The discussion on the value of our American species is fallible as long as the descriptions are not elucidated by figures. I preserve this species on account of the small size and the form of the lateral leaflets, which are much shorter and broader toward the base, sometimes cordate, and also for the more deeply marked nervation. The surface of the leaves is generally runcinate by the depression of the veins and veinlets.

3. EVANSTON, ABOVE THE COAL.

Specimens on a hard, ferruginous shale of the same nature as that of Point of Rocks.*

PHRAGMITES OENENGENSIS, Al. Br. I refer to this species part of a stem about half an inch broad, with primary veins deep, strong, separated by intermediate very thin ones, articulated, marked at the articulation by the round scar of a branch. It is more deeply striated than in most of the specimens figured of this species. Sismonda in Pal. du Piémont, Pl. vi, Figs. 3–5, has a branch of the same kind.

POPULUS RICHARDSONI, Heer, Fl. Arc., p. 98. The specimen is of the same form as the one in Pl. lv, Fig. 3^6, and still better preserved. It is a large ovate-cordate, pointed leaf with borders undulately, obtusely crenate; five primary basilar nerves, the exterior ones much branching outside, the two lowest curving in a very open angle toward the borders; the intermediate ascending more obliquely to near the point; tertiary nervation very distinct.

SALIX EVANSTONIANA, *sp. nov.* Leaf ovate-lanceolate, (?) (upper part broken,) rounded to the base, with apparently entire borders; lower pairs of veins (two pairs) shorter, nearly horizontal; superior ones longer, on a more acute angle of divergence, at various distances from each other, irregular in directions, curving near and along the borders, separated by shorter tertiary veins. This species has the nervation of *S. macrophylla*, Heer, especially as figured in Fl. Ter. Helv., Pl. lxvii, Fig. 4, and our specimen could be referred to it but for the form of the leaf appearing entire, merely ovate-pointed, much shorter, and by the medial nerve, which is narrow proportionally to the thick secondary veins and nervilles. These are distinct, perpendicular to the veins.

CORYLUS MCQUARRII, Heer, Report, p. 292. One specimen bears

* Report, p. 291.

a leaf of this species; another specimen, with leaves of *Juglans rugosa*, has a small nut which seems referable to the same, Hazel. It is slightly shorter and broader than the one figured as *C. McQuarrii*, in Heer's Fl. Arc., Pl. ix, Fig. 5.

MORUS AFFINIS, *sp. nov.* Leaf broadly ovate, truncate-cordate at base, abruptly pointed, with borders irregularly serrate,(?) (the stone is coarse-grained and the borders undistinct.) Secondary veins oblique, (angle of divergence, 30° to 35°,) nearly parallel, the basilar pair only approaching nearer to the superior one in ascending to the borders; all nearly straight, deeply marked, abruptly curving and anastomosing at a short distance from the borders; nervilles distinct, numerous, parallel, branching. The lowest pair, only of secondary veins, is much divided outside in oblique branches, parallel and curving near the borders, like the secondary ones; texture of the leaves apparently thin. Except that the nervilles are more numerous, the nervation and areolation of this species is in every point similar to that of our living *M. rubra*, L., as is also the form of the leaves which in one of the specimens, at least, appears to have one side slightly cut in one lobe. It is regretable that the borders are not distinctly seen. The four specimens of this species have the same characters.

FICUS GAUDINI, Lsqx., Report, p. 300. The specimen is a piece of fine-grained sandstone of the same kind and appearance as that from the unknown locality remarked upon in Report, p. 300, and which therefore should be referred to Evanston. The leaf is identical in characters with those formerly described.

PLATANUS ACEROIDES, Göpp. The leaf preserved nearly entire has the broad nearly truncate base of this species, with secondary basilar veins at an angle of 40°; the lateral lobes are long and pointed too, and therefore the identification is certain. The same specimen, however, bears two leaves of *P. Guillelmæ*, Göpp., whose characters are equally well marked by more oblique basilar veins, borders descending in an acute angle toward the petiole, along which they abruptly pass in a short wing. Heer, at first, united both species for the European specimens, and only admitted them as distinct in examining leaves from the North Greenland Tertiary, (Fl. Arc., II, p. 473.) I am as yet uncertain if this separation is sufficiently authorized. Some specimens of ours are referable to both forms, and, indeed, leaves of our living *P. occidentalis* show in their outlines, and even their nervation, differences which in a fossil state would authorize a separation of species, if seen from separate specimens, more legitimately than from the various forms referable to both the fossil ones. The presence, however, of leaves of a same type upon a same piece of shale, has no weight to decide the question of identity. The trees of the Tertiary, like those of our time, are generally grouped at the same place by a kind of family intimacy: *Juglans nigra* with *Carya alba; Acer saccharinum* and *A. rubrum* species of *Quercus*, &c., and of course their leaves are found side by side upon the ground, though coming from different trees.

CINNAMOMUM SCHEUZERI, Heer. Represented by a poor specimen. The lower part of the leaf is erased and no part of the nervation is distinguishable but the medial nerve and the two lateral veins, ascending to three-fourths of the leaf and curving inward along the borders. It might be referable to *C. polymorphum*, Heer, the leaf being larger than in the common forms of *C. Scheuzeri;* a true *Cinnamomum*, however.

CINNAMOMUM MISSISSIPPIENSE, Lsqx. Two leaves upon the same specimen. They are similar in their characters, even in size, to those

figured from the Mississippi Tertiary in Trans. Am. Phil. Soc., vol. XIII, Pl. xix, Fig. 2.

MAGNOLIA HILGARDIANA, Lsqx.(?) Specimen showing the middle part only of a large leaf with undulate, entire borders and the nervation of this species. On one side of the leaf the secondary veins are slightly nearer to each other and also more oblique than on the other. It is apparently identical.

VITIS OLRIKI, Heer. One of the two leaves referable to this species is well preserved enough to show the nervation and the large entire obtuse teeth of the borders, which mark the specific characters. These leaves, however, are smaller than the fine one figured by the author in Fl. Arc., 1, Pl. xlviii, Fig. 1; broadly cordate, enlarged in a short obtuse lobe above the middle, then more abruptly pointed. It is palmately 5-nerved from the base, the lower pair of veins nearly horizontal; the lateral ones of the same angle as the divisions of the medial nerve, much branching outside; nervilles obsolete; leaf of a thin texture.

FICUS TILIÆFOLIA, (?) Al. Br. A large leaf whose mere outline and skeleton of veins are obscurely marked upon the stone. It is referable as well to *Dombeyopsis æquifolia*, Göpp. The lower part of the leaf is totaly erased.

ACER SECRETA, *sp. nov.* The leaf is seen only in its upper part; showing three deeply cut, lanceolate, long-pointed lobes with undulate borders marked by a few large teeth. The lobes are contiguous, nearly parallel and equal, separated by narrow but obtuse sinuses. The secondary veins are thin, very oblique, (angle of divergence, 25°;) Tertiary nervation obsolete. By its nervation and the mode of division of the borders, this leaf is comparable to *A. pseudoplatanus* var. *paucidentata*, as figured in Gaud., 3d Mem., Pl. iii, Fig. 2, differing, however, much by the deeply cut, lanceolate-pointed, nearly equal and parallel lobes.

RHAMNUS RECTINERVIS, Heer, Report, p. 295.

RHUS DELETA, Heer, Fl. Ter. Helv., III, p. 83, Pl. cxxvii, Fig. 8. Leaves membranaceous, ovate-lanceolate, obtusely pointed, entire; secondary veins open, camptodrome, thick near the base; tertiary nervation obsolete. The specimens agree with the description of the author, showing leaves of the same size more or less enlarged above the rounded base and of the same kind of nervation.

JUGLANS RUGOSA, Lsqx. Many leaves exactly similar in form and nervation to those of Point of Rocks Station. There is a large number of specimens of this species from both localities.

JUGLANS OBTUSIFOLIA, Heer. Leaves broader, enlarged in the middle, apparently obtusely pointed, rounded to the petiole, entire; surface of the leaves deeply runcinate by depression of the secondary veins, which curve near the borders and are equidistant; nervilles and tertiary nervation distinct; appear identical with Heer species, Fl. Ter. Helv., III, p. 89, Pl. cxxix, Fig. 9.

4. FISCHER'S PEAK, RATON MOUNTAINS.

A hard, greenish-yellow, metamorphic sandy shale, with distinct remains of plants, mostly flattened in the plane of stratification.

PTERIS EROSA, *sp. nov.* Leaflets apparently broadly lanceolate or ovate-lanceolate, (?) (the upper and lower part of the leaflet being destroyed,) with irregularly crenulate or lacerate borders; medial nerve thick; veinlets oblique, (angle of divergence, 60°,) straight, mostly simple, some forking, near or at the base, rarely above the middle, distant and parallel. By its nervation and the form of the leaflets, this

species is a true *Pteris*, related by its characters to some varieties of *P. longifolia*, L., with serrate borders. The irregular laceration of the borders may be the result of maceration. The leaflet is not half preserved, the part seen being a little more than 2 inches long and half as broad. This species differs from *P. pennæformis*, Heer, by less oblique, less divided, and more distant veinlets.

PHRAGMITES OENINGENSIS, Al. Br. Stems 1 inch broad or less; coarsely striated with the same characters as those described above from Evanston.

SABAL CAMPBELII, Newy., Notes on Extinct Floras, p. 41, (Pl. x, ined.) There is a large number of specimens all with the same characters. They are referable to this species on account of the very thin, obscure striæ of the rays, whose surface in all the specimens, without exception, appears covered by a smooth, thick epidermis which obliterates the lines. The number of the rays, which are sharply folded, is proportionally very large, a character which, like the first, separates this species from *S. Grayana*, Lsqx., of the Mississippi Tertiary. The author describes the petiole as flat. The upper face is concave, nearly half-cylindrical, and striate like the leaves, except the middle, which is rugose and spongy-like; the lower is convex in the same degree; near its base the petiole flattens and enlarges. The specimens represent different parts of the plant—leaves, petioles, and their sheaths, trunks, fruits, &c.

CARPOLITHES PALMARUM, *sp. nov.* These fruits, described in Report, p. 295, from Evanston, (above the coal,) as *Carpolithes lineatus*, (?) Newby, are found agglomerated in large number upon the same specimens, and mixed with irregular striate woody filaments, thus apearing as derived from decayed bunches, the filaments representing pedicels. These fruits are round oval, varying in length from $1\frac{1}{2}$ to $2\frac{1}{2}$ centimeters, and in width from 1 to $1\frac{3}{4}$ centimeters. Most of them are more or less compressed; some nearly flat, some but little devious from the oval-cylindrical primitive form, which is slightly truncate on one side and conical obtuse on the other, narrowly striate, the lines converging to the truncate part, and there often becoming more inflated and distinct. These fruits are referable to species of Palms, not only on account of their connection with Palm leaves, on the same specimens, but especially in consideration of their form, their apparent texture, and their agglomeration in bunches. Their form is like that of the nuts of some species of *Iriartea—I. setigera*, Mart., for example; or of *Leopoldinia—L. pulchra*, M. and C. They appear to have been surrounded by a thin pulpous coating, under which there was a shelly envelope, still distinguishable on some of the specimens, with a compressible and therefore somewhat soft kernel. The best preserved specimens show differences in forms from conical obtuse to exactly oval except the small truncate point of attachment. These differences may indicate two species. Perhaps *C. lineatus*, Newy., is referable to the same kind of fruits; but none of these specimens are marked by a small point, as in Dr. Newberry's figure, *loc. cit.*

POPULUS MUTABILIS var. *repando-crenata*, Heer, Fl. Ter. Helv., p. 22, Pl. lxii, Fig. 2. A large leaf, the lower part of which is destroyed. It is broadly elliptical-lanceolate, obtusely pointed, with borders undulate-crenate and distant; alternate secondary veins very oblique and curved in ascending to and along the borders. The specimen is obscure, but the essential characters of this species are well preserved enough for identification.

POPULUS MONODON, Lsqx., Trans. Am. Phil. Soc., Vol. XIII, p. 413,

Pl. xv, Figs. 1 and 2. A large leaf, 4 inches broad in its widest part, at least 6 inches long, broadly ovate, lanceolate-pointed, rounded to the petiole; borders entire, undulate; medial nerve thick, secondary veins about 12 pairs, nearly equidistant and parallel, diverging from the medial nerve under an angle of 60°, slightly curved or nearly straight to the borders, where they become obsolete; lower secondary veins branching outside. This species is like the former by the general form of the still larger, longer leaves, from which it differs, however, by its secondary veins, more numerous, less distant, parallel, and by the borders entire. Its nervation is similar to that of *Populus balsamoides*, as figured by Gaudin, Fl. Ital., 1st Mem., Pl. iii, Fig. 1, for the branching and anastomosing of the secondary veins, and Fig. 4, for parallel, less distant veins; the leaf is of a thick texture.

QUERCUS CHLOROPHYLLA, Heer. A specimen, representing a coriaceous smooth leaf, runcinate horizontally, without trace of secondary veins or of tertiary nervation; apparently ovate and entire, the borders being imbedded in the stone. A small leaf upon the same specimen indicates more clearly its ovate form, marking identity with Heer's Fl. Ter. Helv. II, Pl. lxxv, Fig. 8. The medial nerve is proportionally broad.

FICUS ULMIFOLIA, *sp. nov.* Leaves round-oval, 3 inches wide, somewhat longer, with entire undulate borders, at least near the base, where only they are observable; medial nerve thick and grooved; petiole short and hooked; secondary veins more or less distant, parallel, open, (angle of divergence, 60°,) joining the medial nerve in a short, downward curve, or slightly decurrent, straight, or flexuous to near the borders, where they curve upward, with sometimes one outside branch; nervilles oblique to the veins, flexuous, undistinct. The borders of the leaves rounded downward, abruptly curve in descending to the petiole, the lower pair of veins following the same curve. The species is represented by a number of specimens, all more or less incomplete, with the upper part of the leaves mostly destroyed. Their general outline resembles that of some leaves of *Alnus Kefersteinii*, Göpp., differing, however, by entire borders and more open secondary veins. Its nearest relative is *F. borealis*, Heer, Fl. Balt., p. 74, Pl. xxi, Fig. 11, differing equally from this species by more open veins.

PLATANUS GUILLELMÆ, Göpp. The same form as the leaf figured in Heer's Fl. Arc., II, Pl. xlvii, Fig. 1.

LAURUS PADATA, (?) Lsqx., Trans. Am. Phil. Soc., vol. XIII, p. 418, Pl. xix, Fig. 1. All the specimens which I refer to this species have only the lower half of the leaves with obsolete nervation. They are most alike, 12 in number, indicating an obovate or oblanceolate coriaceous leaf, gradually tapering downward to a thick medial nerve. The few distinguishable secondary veins are thin, and have the same direction as in the species quoted above. This is not sufficient to warrant identity. These remains might be referrable to *Persea lancifolia*, Lsqx., *loc. cit.*, Figs. 3 and 4.

CINNAMOMUM MISSISSIPPIENSE, Lsqx., *loc. cit.*, p. 418, Pl. xix, Fig. 2. A good specimen, though merely a little more than the lower half of the leaf is preserved. The leaf is still larger than the one from Mississippi.

ANDROMEDA GRAYANA, Heer. Two specimens, one of which represents a whole leaf, with distinct nervation. The identity with Heer's species, Report, p. 298, is ascertained.

MAGNOLIA LESLEYANA, Lsqx., *loc. cit.*, p. 421, Pl. xxi, Figs. 1 and 2.

Two nearly entire leaves of this species, of exactly the same form and characters as those described from specimens of the Mississippi Tertiary.

MAGNOLIA HILGARDIANA, Lsqx., *loc. cit.*, p. 421, Pl. xx, Fig. 1. The borders of the leaves which I refer to this species are mostly erased. These leaves are oblong, not enlarged upward, as in the former species, abruptly rounded downward to the petiole; secondary veins numerous, parallel, open, curving at a short distance from the borders and along them. The general outline of these leaves and their nervation agree in in every point with description and figure, *loc. cit.*

Among the undeterminable fragments from this locality, there are still some referable to another species of *Magnolia*, especially resembling, by obtuse point and nervation, *Magnolia ovalis*, Lsqx., also of the Mississippi Tertiary.

TERMINALIA RADOBOJENSIS, Heer, not Ung. The same leaf, in all its characters, as the one figured in Fl. Ter. Helv., Pl. cviii, Fig. 12. It is entire, obovate, gradually tapering downward to the base of the medial nerve; secondary veins distant, opposite or alternate, irregular in distance and direction, at first curving outside from the medial nerve, and then ascending nearly straight to the borders, camptodrome. Traces of strong nervilles perpendicular to the secondary veins, and also of a few intermediate tertiary shorter veins, are obscurely seen on the specimen, the substance of the leaf appearing somewhat thick. Unger's figure of this species in Chloris, Pl. xlviii, Fig. 2, represents a much larger leaf, with secondary veins more numerous, equally distant, parallel, and an ultimate nervation finely marked, as in a leaf of a thin texture. These differences may be considered as specific.

RHAMNUS OBOVATUS, Lsqx. The leaf is smaller than those described from Marshall coal in Am. Jour. Sci. and Arts, vol. 45, p. 207. The peculiar form of the obovate or oblanceolate leaves with closely approached, parallel, thick secondary veins identify them easily.

RHAMNUS DELETUS, (?) Heer, Fl. Ter. Helv., p. 79, Pl. cxxiii., Figs. 19–23. Two broken specimens are referable to this species. They represent ovate, slightly cordate leaves, with 8 to 10 pairs of deeply marked secondary veins, slightly curving in passing to the borders, camptodrome with distinct fibrilles. The point of the leaf is destroyed and thus the essential character of this species—borders serrulate near the point—is not ascertainable.

BERCHEMIA PARVIFOLIA, Lsqx., Am. Jour. Sci. and Arts, vol. 45, p. 207. The name given to the species is not appropriate, as a new specimen from this locality has a leaf as large as in *B. volubilis*, D. C. From this it differs by broader leaves and secondary nervation more open, the veins slightly arched in ascending and bending upward before reaching as near the borders. This species is still more closely allied to *B. multinervis*, Heer, Fl. Ter. Helv., p. 77, Pl. cxxiii, Figs. 9–18, differing merely by the secondary veins, which, in the American species, are open from the medial nerve, while in Heer's species they join the nerve by a downward curve.

RHAMNUS FISCHERI, *sp. nov.* Leaves thickish, large, 4 inches long, 3 inches broad, rhomboidal, obtuse and entire; medial nerve, thick, grooved, secondary veins open, (angle of divergence, 60°,) equidistant, 10 to 12 pairs, parallel, straight to the borders, where they abruptly curve, camptodrome. By the form of the leaves and the straight secondary veins this species is related to *Rhamnus aizoon*, Heer. The nervilles are not distinguishable.

XANTHOXYLUM DUBIUM, *sp. nov.* A small oblong leaf 3 centimeters long, 1½ centimeters broad, with borders entire or wavy crenulate, nearly

parallel in the middle, rounded downward, with an abrupt short descending curve to the base of the medial nerve. Secondary veins parallel, 8 pairs, open, (angle of divergence, 60°,) abruptly curving near the borders, camptodrome. The point of the leaf is destroyed. Related to *X. dentatum*, Heer, Fl. Ter. Helv., Pl. cxxvii, Fig. 21.

JUGLANS SMITHSONIANA, *sp. nov.* Leaves smooth, lanceolate, tapering into a long point, deeply undulate, abruptly curving downward, to the petiole, medial nerve flat and broad; lowest pair of secondary veins very oblique, running to and curving along the borders opposite; the other pairs alternate, distant, irregular in direction, curving also in ascending to and along the borders; tertiary nervation obsolete. A fine species represented by only one specimen, resembling by its nervation *J. Baltica*, Heer, Fl. Balt., Pl. xxix, Fig. 10, and by its general form *J. Schimperi*, Lsqx., described above, a true *Juglans*, though the leaf appears somewhat thick or coriaceous.

5. PLACER MOUNTAIN, NEW MEXICO.

A coarse, blackish, hard, metamorphic sandstone, with obscure remains of leaves; few of the specimens of this locality are distinct enough to allow positive identification of the leaves.

POPULUS BALSAMOIDES, Göpp. One leaf only, broadly ovate-cordate, abruptly narrowed to a point; medial nerve narrow; secondary veins numerous, 11 to 12 pairs, open, parallel, curving to and along the borders, (camptodrome.) The borders are apparently entire; but the coarseness of the stone prevents ascertaining it positively. It may represent a new species, differing from *P. balsamoides* by more numerous and parallel secondary veins. These veins appear to curve upward quite near the borders, and to join the superior divisions as in our *P. balsamifera*, L., var. *candicans*.

QUERCUS PLATANIA, (?) Heer. A mere fragment which agrees only by its nervation. Another broken specimen of the same character has the veins less distant, and agrees by its general outline and nervation with *Q. Olafseni*, Heer. Both appear to represent the same species of a *Quercus* as yet undeterminable.

FICUS TILIÆFOLIA, Heer. Only part of a leaf whose nervation is distinctly preserved and undoubtedly referable to this species. Another leaf of *Ficus* has the lateral basilar veins alternate as in *F. Morloti*, Heer, Fl. Ter. Helv., Pl. lxxxii, Fig. 8.

PLATANUS GUILLELMÆ, Heer. Represented by a number of specimens, all fragments, scarcely recognizable.

CINNAMOMUM MISSISSIPPIENSE, Lsqx. It differs by the secondary veins, not quite as thick, ascending, in the upper part of the leaves along the borders, as in some leaves of *C. Buchi*, Heer, Fl. Ter. Helv., Pl. xcv, Fig. 3. This difference is not characteristic. As remarked in my description of this species, *loc. cit.*, p. 418, the reversed figure of *C. Buchi*, represents exactly by its form that of *C. Mississippiense.*

MAGNOLIA! Species undeterminable, mere fragments.

CARPOLITHES SPIRALIS, *sp. nov.* A hard fruit of a remarkable form. It is oval-cylindrical, obtuse at one end, truncate at the other, 2 inches long, half as broad, obtusely narrowly ribbed, the ribs ascending in spiral around it from its truncate base, above which it is slightly contracted by two deep parallel lines, cutting the ribs at a right angle without changing their direction. I do not know any fruit to which this might be compared.

CARPOLITHES COMPOSITUS, *sp. nov.* It looks like a compound of

flattened almonds, attached at their point and pressed together. It is divided upward in four unequal lobes, the two of the middle being longer and more flattened or narrower; the other shorter, more inflated, divided to half their length, which varies from $\frac{1}{4}$ to $\frac{1}{2}$ of an inch, and truncate at the lower end. The relation of this species is, like that of the former, unknown to me.

CARPOLITHES MEXICANUS, *sp. nov.* Much like some of the nuts described above as *C. palmarum*, differing, however, by its exactly ovate-cylindrical, pointed form.

6. HOT SPRINGS, MIDDLE PARK.

A piece of hard siliceous tufa or grit.

JUGLANS THERMALIS, *sp. nov.* Leaf ovate, lanceolate, cuneate-pointed, rounded in narrowing to the petiole, (broken,) 5 inches long, about 2 inches broad; medial nerve sharp and narrow; secondary veins irregular in distance and direction; the lowest pair more oblique, separated by horizontal tertiary veins anastomosing with branches of the secondary. Nervation analogous to that of *J. obtusifolia*, Heer, Fl. Ter, Helv., Pl. cxxix, Fig. 9; form of leaf like *J. longifolia*, Heer, *loc. cit.*, Fig. 10. It might be identical with this last species, of which the only leaf figured does not represent the tertiary nervation.

GENERAL REMARKS.

GREEN RIVER, ABOVE FISH BEDS.

The geological station of this place, from indication of the fossil plants described, appears to be of a different stage from that of any of the other localities which have furnished materials for the present examination. In the former report, p. 289, the station of Green River is left indeterminate, one species only, *Ceanothus cinnamomoides*, being recognizable from the few specimens then on hand. Now we have besides this one, still found in the newly received lot of specimens, twenty-one species affording data for comparison. Except the omnipresent forms of the Tertiary, *Arundo*, *Phragmites*, and *Juncus*, all these plants bear a more recent facies than the species of Evanston, Point of Rocks, and Fischer's Peak, especially by their relation to living species—*Ceanothus cinnamomoides*, comparable to some of the numerous species of California; *Myrica nigricans*, allied to our *Myrica Gale*, L.; *Ficus Ungeri*, to *Ficus Americana; Ampelopsis tertiaria*, to the well-known *Ampelopsis quinquefolia*, Michx.; *Ilex affinis*, scarcely distinguishable from *Ilex coriacea*, Chap., of Florida; *Rhus acuminata*, related to our common *Rhus aromatica*, L.; and *Eucalyptus Americanus*, to some species of this genus, inhabiting Australia. From these new species *Juglans Schimperi* is the only one which does not appear related to any of the present flora. Of the species of Green River described already from the Miocene of Europe, *Salix augusta*, apparently identical with the living *Salix viminalis*, L., and *Salix media*, are both from Oeningen, or from the upper stage of the Miocene; *Myrica salicina*, *Quercus lonchitidis*, and *Ilex stenophylla*, have representatives in both the Upper and the Middle Miocene; *Ficus populina*, only, belongs to the Lower Miocene; but as seen from the description, our American form differs in some points from the European, and may prove to be a different species. As related to Arctic types, we have only from Green River *Juglans denticulata*, (?) which, if not identical with the Greenland species, is at least closely allied to it.

The relation of all these species, therefore, except the *Cyperaceæ*, &c., found everywhere, is evidently with younger types, and indicates a higher station in the Tertiary measures. From the absence of the species which characterize the American formation considered as Eocene, and also from the absence of the Arctic types, which become less predominent in advancing toward our present epoch, the fossil plants of Green River apparently represent the Upper Miocene.

POINT OF ROCK STATION.

The horizon of this station, like that of the former, was left undetermined in the Report, p. 308, the few specimens received from it indicating only one *Cyperites*, *Fagus Antipofi*, and indistinct leaves referable to *Juglans* and *Platanus*. Nine species have been added to this short list, from a new contribution of specimens; but as none of them is characteristic of a peculiar horizon, the geological station of this place is not positively ascertainable. Of these species, *Corylus McQuarrii*, *Populus arctica*, and *Platanus Guillelmæ* are represented in the formation considered as Eocene, the first at 6 miles above Spring Cañon, the two last at Evanston; but they have been found also in connection with strata referred to the lower Miocene—Medicine Bow, Washakie, and Junction Station. *Juglans rugosa* is distributed through the whole thickness of the American Tertiary, apparently at least; the other species, *Cornus rhamnifolia*, is found in all the stages of the European Miocene. From the presence of a number of Arctic types, *Populus arctica*, *Platanus Guillelmæ*, *Vitis Islandica*, *Fagus Antipofi*, which are absent from the Green River formation; I believe, however, that Point of Rocks occupies a lower stage in the Tertiary, though higher than Evanston, and that therefore its place is in the Lower Miocene. This supposition is essentially indicated by the absence of any of the species marked as characteristic of the American Eocene.

EVANSTON.

A lot of specimens representing especially species of *Ficus* is marked in the former report, page 300, as of unknown origin. The lithological characters of these specimens and the analogy of the species which they bear, refer them to the same strata as those marked "*Evanston, below the coal.*" At the same place, the upper strata show evidently by their remains of plants, representatives of a flora of the same age as the lower ones; for two of the four species recognized above the coal are found also below it. Adding to this number the species described in these notes, we have a list of 42 species of fossil plants for Evanston; a larger number than from any other locality of the American Tertiary. This place may therefore be considered as a point of mark, used for future references and comparisons.

Considered in its whole or in its details, the large list of the species of Evanston do not indicate any character which might modify the opinion formerly advanced on the age of the formation. Except *Morus affinis*, closely allied to our living *Morus rubra*, all the other fossil plants represent older Tertiary types. It is undeniable that without any exception most of these types of ours compared with European fossil species should be referable to the Miocene. But as said in Report, pp. 313 and 314, either these species belong to the American Eocene or as yet this formation is unknown in our geology.

The relation of Evanston with the Mississippi Tertiary flora is

now marked by three distinct species which they have in common—*Juglans appressa*, *Cinnamomum Mississippiense*, and *Magnolia Hilgardiana*. But it is evidently a geological and not an isothermal relation; for all the Arctic types described from Evanston—*Populus arctica*, *Populus Richardsoni*, *Corylus MacQuarrii*, *Vitis Olriki*, &c.—are absent from the Tertiary of the Mississippi.

FISCHER PEAK, RATON MOUNTAINS.

By far the most interesting locality, on account of the data derived from it, for comparison of geological station as also of geographical distribution, is that of Fischer's Peak, in the Raton Mountains, north of the New Mexico Territory. On one side, the fossil flora of this locality affords evidence of the same age as that of Evanston and of the Mississippi, referable to both by the more remarkable species recognized from its specimens. With Evanston, it has in common, *Populus mutabilis*, *Platanas Guillelmæ*, *Cinnamomum Mississippiense*, *Andromeda Grayana*, *Magnolia Hilgardiana*, *Carpolithes palmarum*, or six species in the twenty-two determined from its remains. With the Mississippi Tertiary flora it has as identical species, *Populus mutabilus*, *Populus monodon*, *Quercus chlorophylla*, *Laurus pedata*, *Cinnamomum Mississippiense*, *Magnolia Lesleyana*, *Magnolia Hilgardiana*, *Juglans appressa*, or eight species. If we consider that this identity is for representatives of genera of distant affinity, which at the same time are all, except *Cinnamomum*, characteristic of our present flora—*Populus*, *Quercus*, *Magnolia*, *Juglans*, even *Palms*; if we consider still that this identity is rendered positive by the peculiar and easily ascertained characters of the species, we can but see here and acknowledge an evident proof of the homogeneity of the North American Tertiary flora in comparing it even at great distances under the same latitude. The difference between the two points of comparison is about 15° of longitude. On another side, this identity of species with Evanston by a few Arctic types—*Populus mutabilis*, *Platanus Guillelmæ*, *Andromeda Grayana*, and by southern types like *Quercus chlorophylla*, *Laurus pedata*, two *Magnolias*, fruits of the Palms—positively confirm the assertion of the former report, p. 311, that though the Tertiary flora of the Northwest is connected by identical forms with the Arctic flora of the same epoch, it already indicates, by a number of its species, climatic differences, according to latitude, as distinct as we see them in the arborescent vegetation of our time. Palm-trees at the Eocenic times were mixed to the flora, not only at Evanston but farther North at Fort Union. But at Fischer's Peak remains of Palms are more numerous nearly one-half of the specimens of this locality representing fragments of leaves, fruits, stems, &c., of a Sabal. In the Mississippi specimens, the remains of two species of Palm are equally abundant.

REMARKS ON TYPICAL ANALOGY OF OUR PRESENT FLORA WITH THAT OF THE TERTIARY.

Little can be said on this question in addition to the remarks in Report, p. 314. The analogy of types of our present flora with those of the Tertiary becomes more evident in proportion to the progress of the researches. Two more of the North American genera of the present time are now recognized in the Northwest Tertiary—*Morus* and *Ampelopsis*. The discovery of a fossil species of Mulberry does not indicate for this country the origin of the numerous species of the same genus which have now representatives in the tropical regions of the whole world, but

it proves at least that ours is truly indigenous. The similarity of the fossil leaves with those of the living species confirms the assertion. And the antiquity of race, too, may be indicated by the wide range of distribution and general prevalence of *Morus rubra*, from Florida to Lake Erie. No species of *Morus* has been as yet recognized in a fossil state. It is the same with *Ampelopsis*, a genus still more evidently North American than *Morus*; for no species of true *Ampelopsis* is known from another country.* The relation of form between the fossil species *Ampelopsis tertiaria* and the living *A. quinquefolia* is as distinctly marked as for the two species of *Morus*, and also its geographical distribution and its predominance in our flora. Both species are in intimate affinity to our North American vegetation. They are seen everywhere and known and liked by everybody. The one is the friend of the farmers by its shade, of his children delighted by the pleasantness of its fruits; the other adorns our dwellings when allowed to grow in our gardens. And when left to its own work, it covers with green foliage the dead trees and the barren rocks, tempering desolation and ruin by hiding them under elegant fringes and garlands painted of the richest colors. It is worth something to know that the origin of the Virginian Creeper and of the Red Mulberry is traceable to the Tertiary formations of North America.

There is still a number of genera from our arborescent flora which have not, as yet, any representatives recognized in the Tertiary—*Asimina*, for example, *Aesculus*, *Hamamelis*, some *Rosaceæ*, *Ericaceæ*, &c. The preservation and fossilization of leaves is more or less dependent upon the consistence of their texture, thin leaves being mostly destroyed by maceration too soon to leave distinct traces of their forms when imbedded in clay or sand deposits. In examining, upon the ground, the dead leaves of our forests in spring, the difference in the degree of preservation resulting of texture is easily remarked. For example, upon a lot occupied by Oak, Beach, Elm, and Maple trees, in nearly equal proportion, the leaves of the three first kinds will be found heaped everywhere and entire, while scarcely a few skeletons of decaying leaves of Maple are distinguishable. This probably explains the absence of some species, and also the disproportion of representatives of others in the Tertiary; as, for example, of the species of *Acer*, which, already predominant at the Cretaceous epoch, and having a large number of species in the present flora of our North American continent, have been as yet rarely found in our Tertiary formations. It must be said, too, that we know as yet but a very small part of the vegetation of the Tertiary, and that every new lot of specimens affords materials to modify suppositions which might be offered on the causes of the distribution of species. In the former report I alluded to the scarcity of the remains of Willows in our Tertiary, in comparison with their great number in the Cretaceous. In the present notes, four species of *Salix*, as yet unknown in our fossil flora, have been described, and probably a number of others will be found still.

However, it is true that some of our ancient types have disappeared, or show a tendency to disappear from our present flora, the types related to the present vegetation of Australia, for example, *Eucalyptus* of the Tertiary, which will be probably found in the Cretaceous with *Phillocladus* and *Proteoides;* some others also, now marked in the flora of Japan and China, which appear to have traveled westward, as *Cin-*

* *Ampelopsis botria*, D. C., is described from Zanzibar, Africa. As it has simple leaves and fruit eatable, it is probably referable to *Vitis*.

namomum and *Ficus* of the Tertiary, and the *Credneria*, with analogous types, of the Cretaceous. *Cinnamomum* and *Ficus*, however, have not left altogether our North American continent, but they have lost their importance in the vegetation of ours, at least compared with the place which they occupied in the Tertiary times.

Each formation, of course, has lost some of its vegetable types in acquiring new ones. The march of the increase and decrease of the typical representatives, the search for appreciable causes which may have fostered modifications of forms, is one of the most interesting parts of the study of vegetable paleontology.

On this subject, it is already evident, to my mind at least, that the *data* presented in these notes, and in the former report of Dr. Hayden, indicate a remarkable analogy of our present flora with that of the Tertiary, and of this, too, with the flora, considered as of the North American Cretaceous, pointing out its ancient origin. But the indications are not yet conclusive. The chain in the modifications of types from the oldest formations (Upper Cretaceous) to the newer ones, (Upper Tertiary,) and from these to our flora, appears especially defective in its last link, our knowledge with the Pliocene flora being as yet too limited. The only locality, known to me, where strata of this age, with remains of fossil plants, are xposed, is, as remarked in Report, p. 318, at Columbus, Kentucky, on what is called the chalk-banks of the Mississippi. The plants which I obtained there, in a too short tour of exploration, are, to my opinion, scarcely, if at all, distinguishable from species now living in the Southern States. I then identified, as far as identity can be ascertained from fossil leaves, *Quercus virens*, Michx.; *Castanea nana*, Muhl.; *Ulmus alata*, Michx.; *Planera Gmelini*, Michx.; *Prinos integrifolia*, Ell.; *Ceanothus Americanus*, L.; *Carya olivæformis*, Nutt; *Gleditchia triacanthos*, L.; and *Acorus calamus*, L. Professor Heer, to whom I sent sketches of the leaves representing these species, objected to my determinations, at least for some of them, and I have no doubt but that he is right in some points. However, the identity of a number, at least, of the species, is undeniable, indicating, therefore, an intimate relation of our arborescent flora with that of the Pliocene. It would be important to obtain a series of specimens numerous enough to give positive evidence of the degree of that relation. The deposits of leaves above Paducah belong to a more recent epoch, the Terrace epoch, apparently. All the specimens of leaves obtained from this formation represent, without doubt, even in the opinion of Heer, species of our time. In following, then, the researches for the purpose of studying the march in the flora from the Cretaceous times till ours, the strata of the West and those of the Mississippi could furnish documents for such a clear record as none other could be got elsewhere on the same subject.

For conclusion it is right to recall in a few words the essential points marked in this examination:

1st. It adds to our list of fossil species of the Tertiary 20 new forms, and describes 21 others, known already from the Miocene of Europe, but not as yet observed in our Tertiary flora. The number of its species is thus increased to 231.

2d. It fixes the geological horizon of three localities in different stages of the Tertiary, and marks the location of a group of specimens of as yet unknown origin.

3d. It more distinctly points out the relation of some important strata for ascertaining contemporaneity or difference of age.

4th. It indicates more positively modifications in the characters of the Tertiary flora of the North American continent according to climatic

differences at different degrees of latitude, and at the same time recognizes identity of the characters of this vegetation at wide distances under the same latitude.

5th. It shows a more intimate relation between the present flora and that of the Tertiary by the discovery of new types identical in both.

The outlines of our Tertiary formations are, from former researches, recognized by their flora in Vancouver, Oregon, Alaska, Greenland, Connecticut, Kentucky, and Mississippi. Under the systematic and judicious directions of Dr. Hayden, its central area is diligently studied in the Northwestern Territories, and every year adds to the value and the importance of the materials furnished for the study of its fossil vegetation. And now Professor J. D. Whitney sends from California a large number of specimens obtained there from the Cretaceous and from different stages of the Tertiary formation. We may thus foresee that in a short time North America will contribute for the acquaintance of the flora of these formations documents reliable enough to afford a secure basis for its detailed and comparative history.

COLUMBUS, OHIO, *May* 4, 1872.